FIG. 1(a)

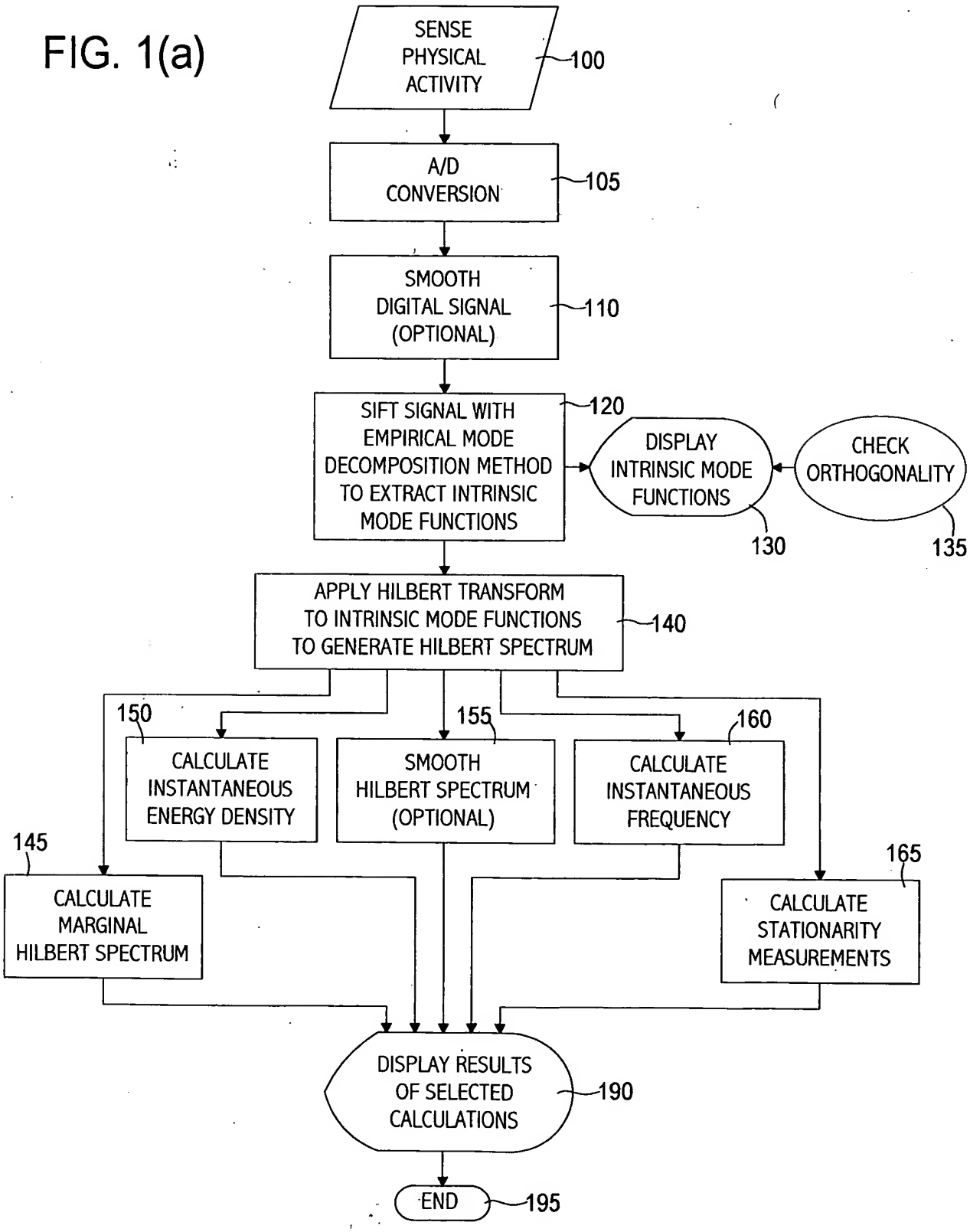

SENSE PHYSICAL ACTIVITY
100
A/D CONVERSION
105
SMOOTH DIGITAL SIGNAL (OPTIONAL)
110
SIFT SIGNAL WITH EMPIRICAL MODE DECOMPOSITION METHOD TO EXTRACT INTRINSIC MODE FUNCTIONS
120
DISPLAY INTRINSIC MODE FUNCTIONS
130
CHECK ORTHOGONALITY
135
APPLY HILBERT TRANSFORM TO INTRINSIC MODE FUNCTIONS TO GENERATE HILBERT SPECTRUM
140
150
CALCULATE INSTANTANEOUS ENERGY DENSITY
155
SMOOTH HILBERT SPECTRUM (OPTIONAL)
160
CALCULATE INSTANTANEOUS FREQUENCY
145
CALCULATE MARGINAL HILBERT SPECTRUM
165
CALCULATE STATIONARITY MEASUREMENTS
DISPLAY RESULTS OF SELECTED CALCULATIONS
190
END
195

FIG. 1(b)

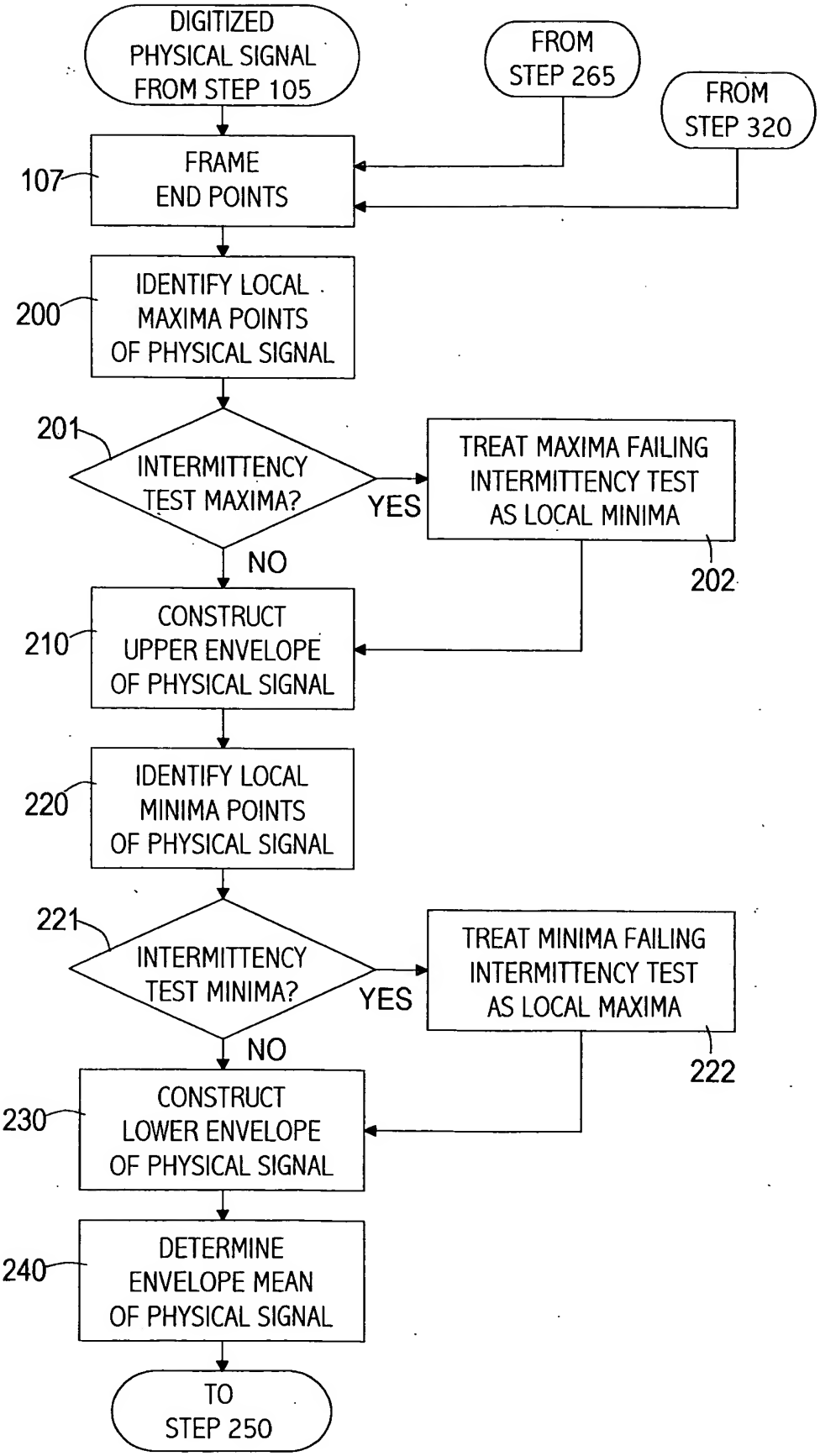
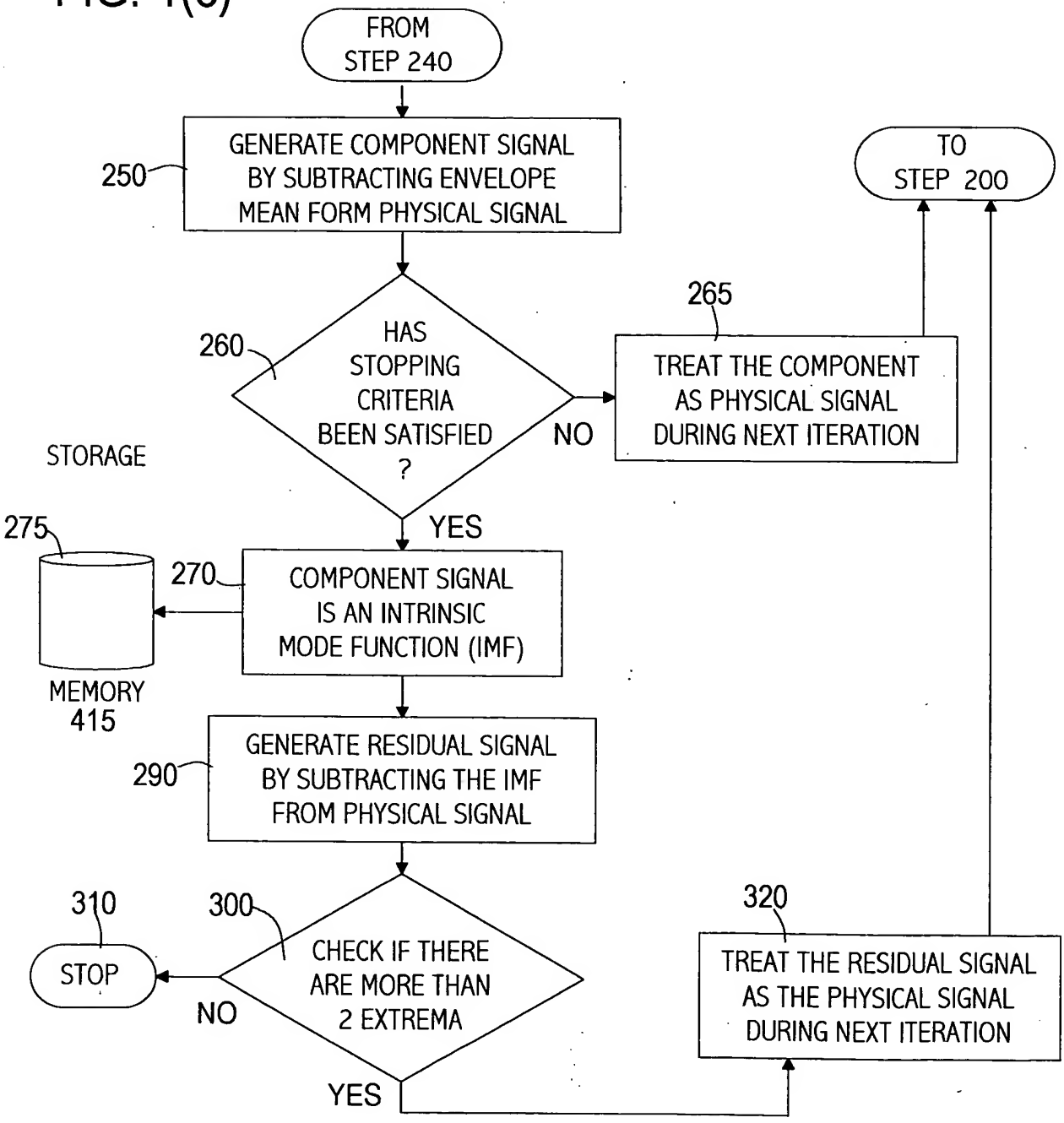

DIGITIZED PHYSICAL SIGNAL FROM STEP 105
FROM STEP 265
FROM STEP 320
107
FRAME END POINTS
200
IDENTIFY LOCAL MAXIMA POINTS OF PHYSICAL SIGNAL
201
INTERMITTENCY TEST MAXIMA?
YES
TREAT MAXIMA FAILING INTERMITTENCY TEST AS LOCAL MINIMA
202
NO
210
CONSTRUCT UPPER ENVELOPE OF PHYSICAL SIGNAL
220
IDENTIFY LOCAL MINIMA POINTS OF PHYSICAL SIGNAL
221
INTERMITTENCY TEST MINIMA?
YES
TREAT MINIMA FAILING INTERMITTENCY TEST AS LOCAL MAXIMA
222
NO
230
CONSTRUCT LOWER ENVELOPE OF PHYSICAL SIGNAL
240
DETERMINE ENVELOPE MEAN OF PHYSICAL SIGNAL
TO STEP 250

FIG. 1(c)


FROM STEP 240
250
GENERATE COMPONENT SIGNAL BY SUBTRACTING ENVELOPE MEAN FORM PHYSICAL SIGNAL
260
HAS STOPPING CRITERIA BEEN SATISFIED ?
NO
265
TREAT THE COMPONENT AS PHYSICAL SIGNAL DURING NEXT ITERATION
TO STEP 200
YES
STORAGE
275
MEMORY 415
270
COMPONENT SIGNAL IS AN INTRINSIC MODE FUNCTION (IMF)
290
GENERATE RESIDUAL SIGNAL BY SUBTRACTING THE IMF FROM PHYSICAL SIGNAL
310
STOP
300
CHECK IF THERE ARE MORE THAN 2 EXTREMA
NO
YES
320
TREAT THE RESIDUAL SIGNAL AS THE PHYSICAL SIGNAL DURING NEXT ITERATION

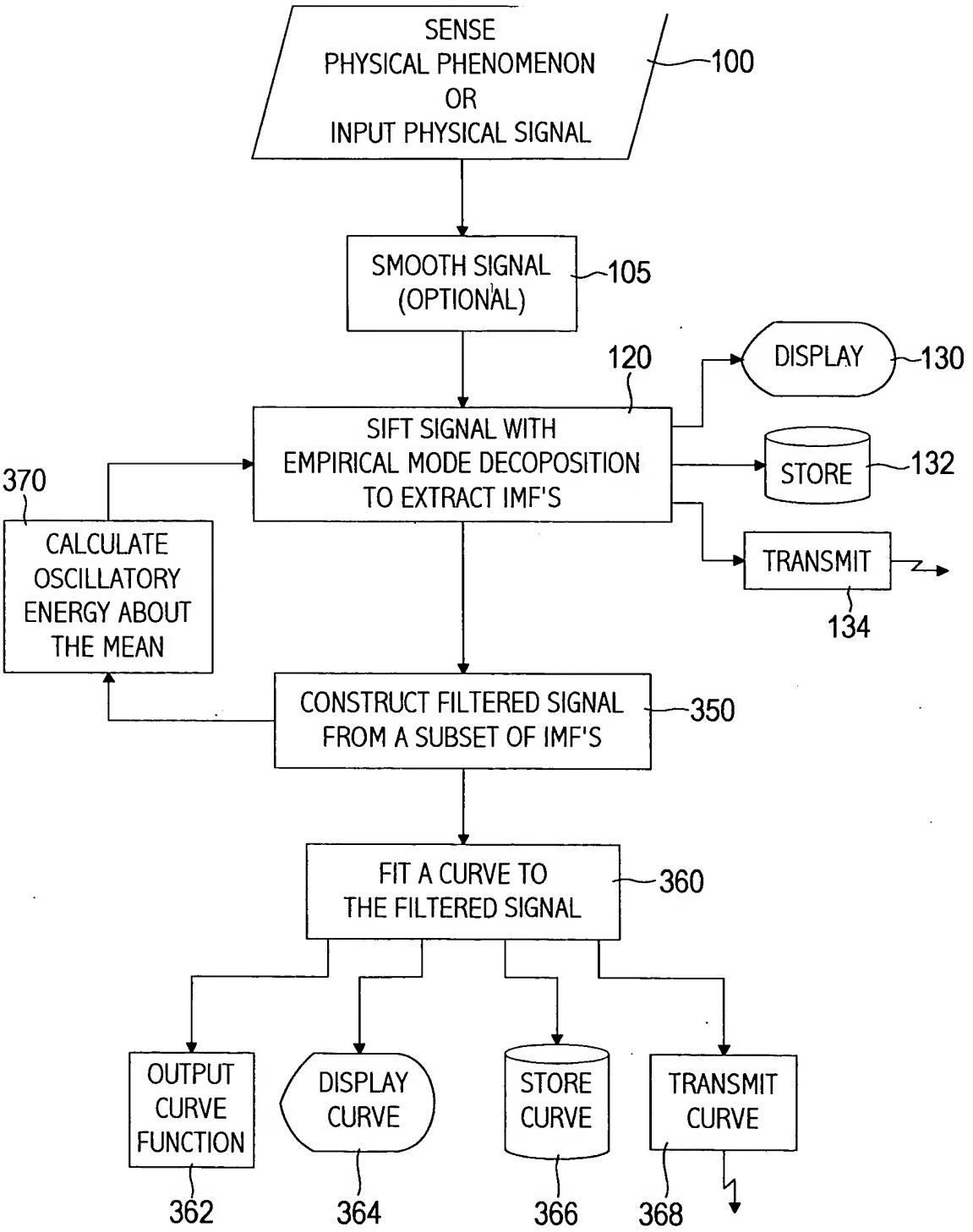

SENSE
PHYSICAL PHENOMENON
OR
INPUT PHYSICAL SIGNAL
100
SMOOTH SIGNAL
(OPTIONAL)
105
120
SIFT SIGNAL WITH
EMPIRICAL MODE DECOPOSITION
TO EXTRACT IMF'S
DISPLAY
130
STORE
132
TRANSMIT
134
370
CALCULATE
OSCILLATORY
ENERGY ABOUT
THE MEAN
CONSTRUCT FILTERED SIGNAL
FROM A SUBSET OF IMF'S
350
FIT A CURVE TO
THE FILTERED SIGNAL
360
OUTPUT
CURVE
FUNCTION
362
DISPLAY
CURVE
364
STORE
CURVE
366
TRANSMIT
CURVE
368

FIG. 1(d)

FIG. 2

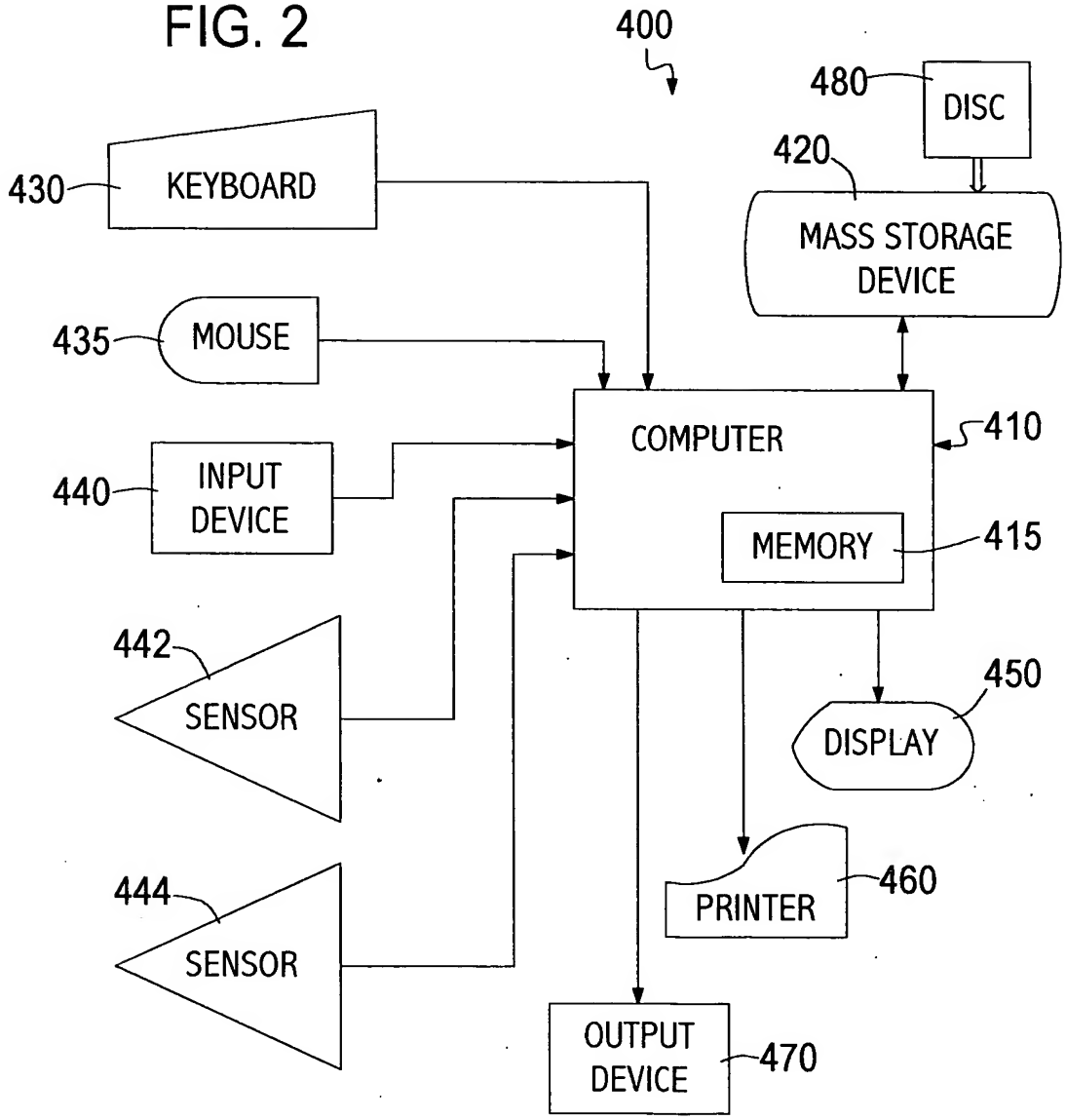

400
480
DISC
420
MASS STORAGE DEVICE
430
KEYBOARD
435
MOUSE
440
INPUT DEVICE
COMPUTER
410
MEMORY
415
442
SENSOR
450
DISPLAY
444
SENSOR
PRINTER
460
OUTPUT DEVICE
470

FIG. 3(a)

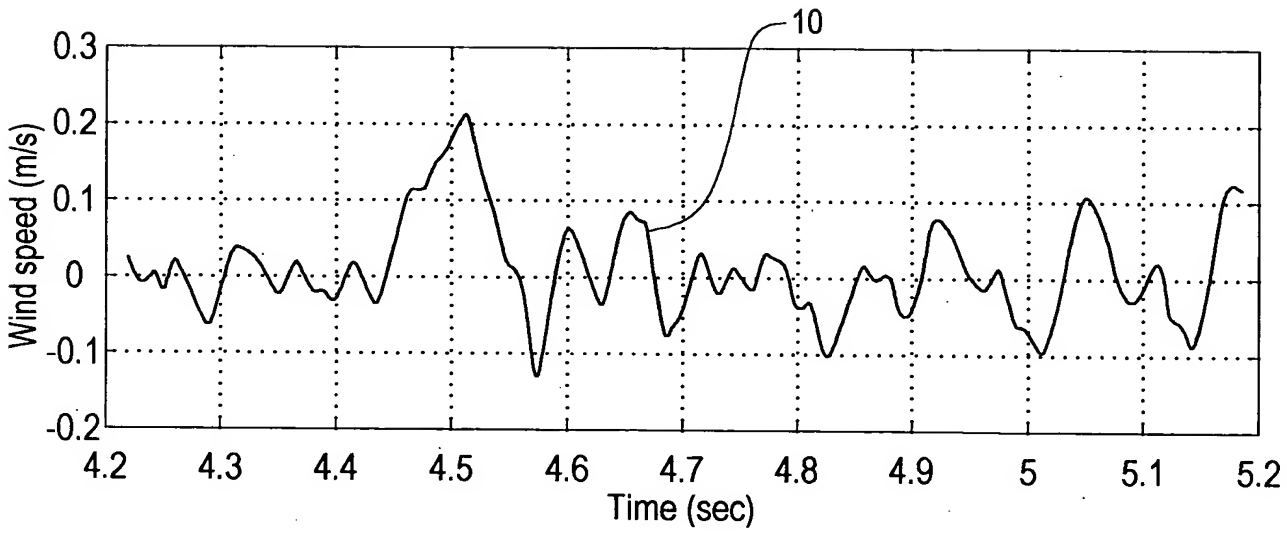

10
0.3
0.2
0.1
0
-0.1
-0.2
Wind speed (m/s)
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
5
5.1
5.2
Time (sec)

FIG. 3(b)

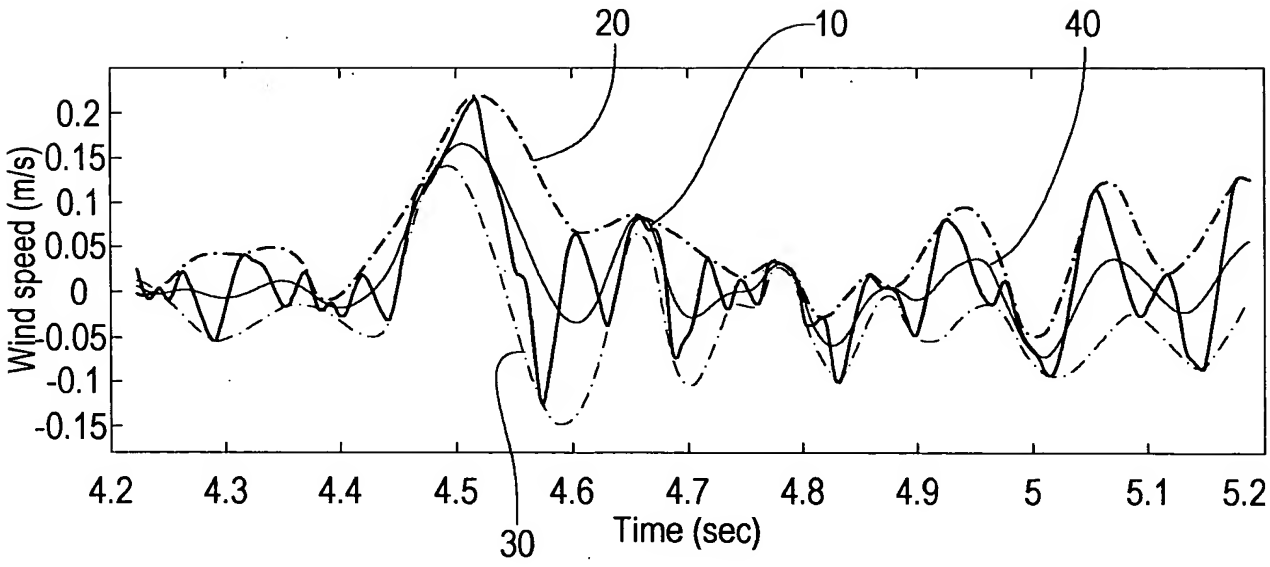

20
10
40
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
Wind speed (m/s)
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
5
5.1
5.2
Time (sec)
30

FIG. 3(c)

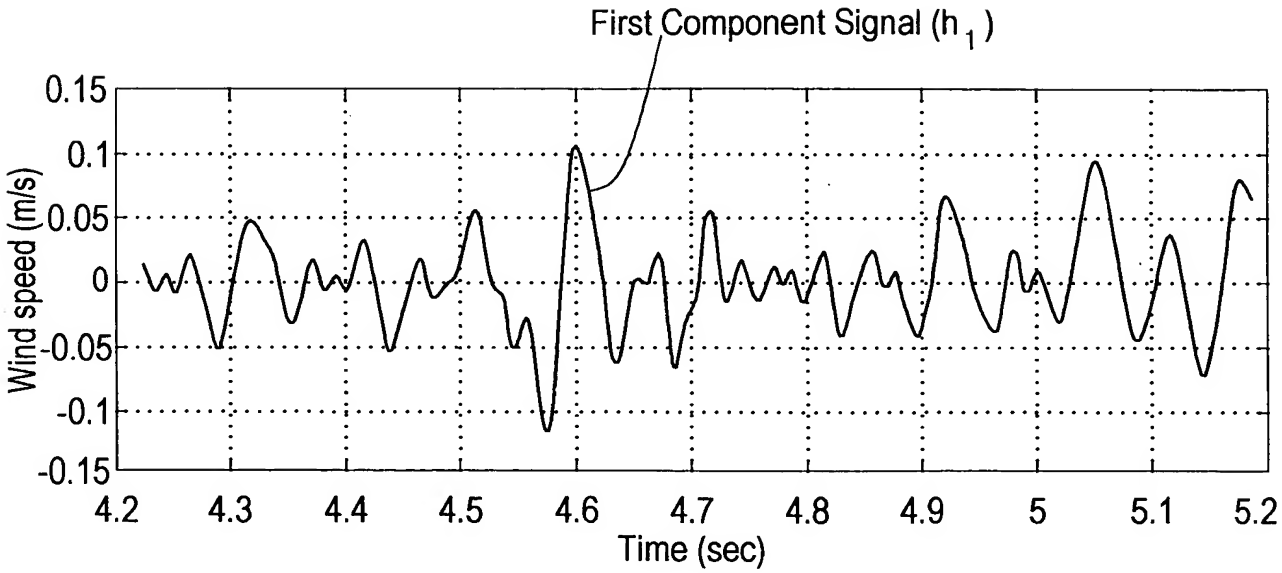

First Component Signal (h_1)
Wind speed (m/s)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
5
5.1
5.2
Time (sec)

FIG. 3(d)

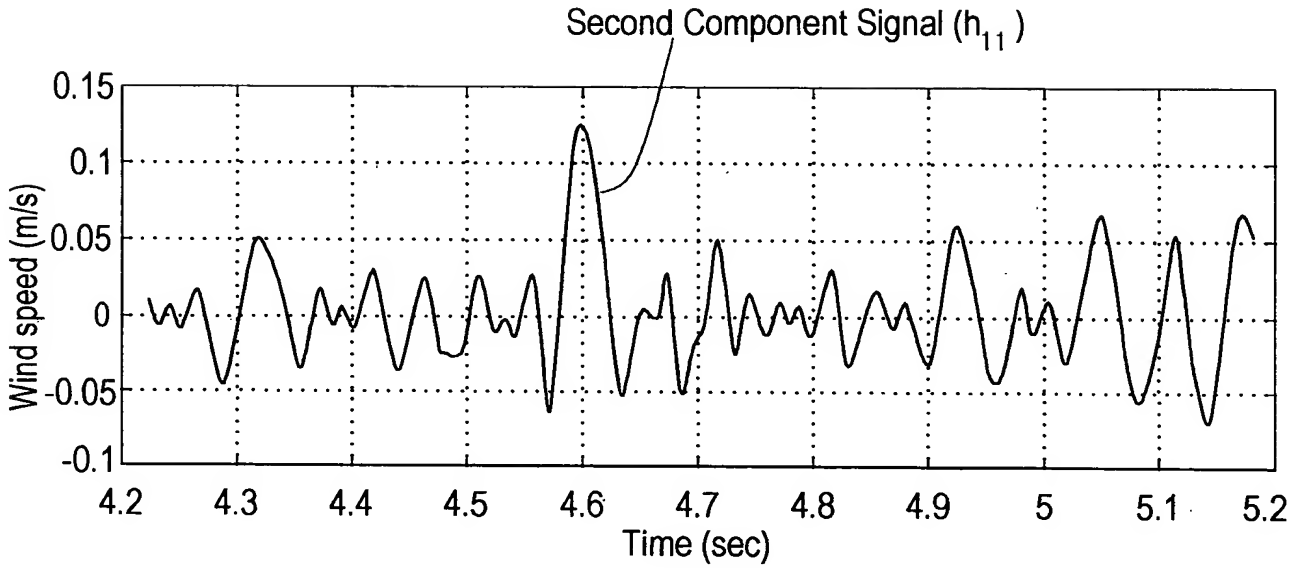

Second Component Signal (h_{11})
0.15
0.1
0.05
0
-0.05
-0.1
Wind speed (m/s)
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
5
5.1
5.2
Time (sec)

FIG. 3(e)

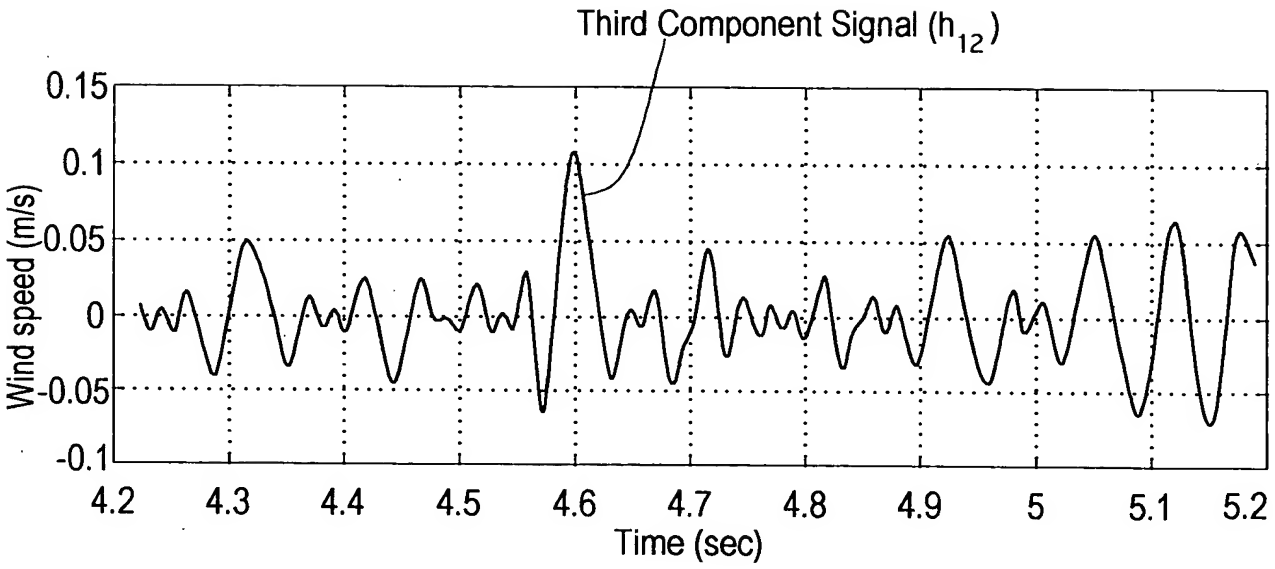

Third Component Signal (h_{12})
0.15
0.1
0.05
0
-0.05
-0.1
Wind speed (m/s)
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
5
5.1
5.2
Time (sec)

FIG. 3(f)

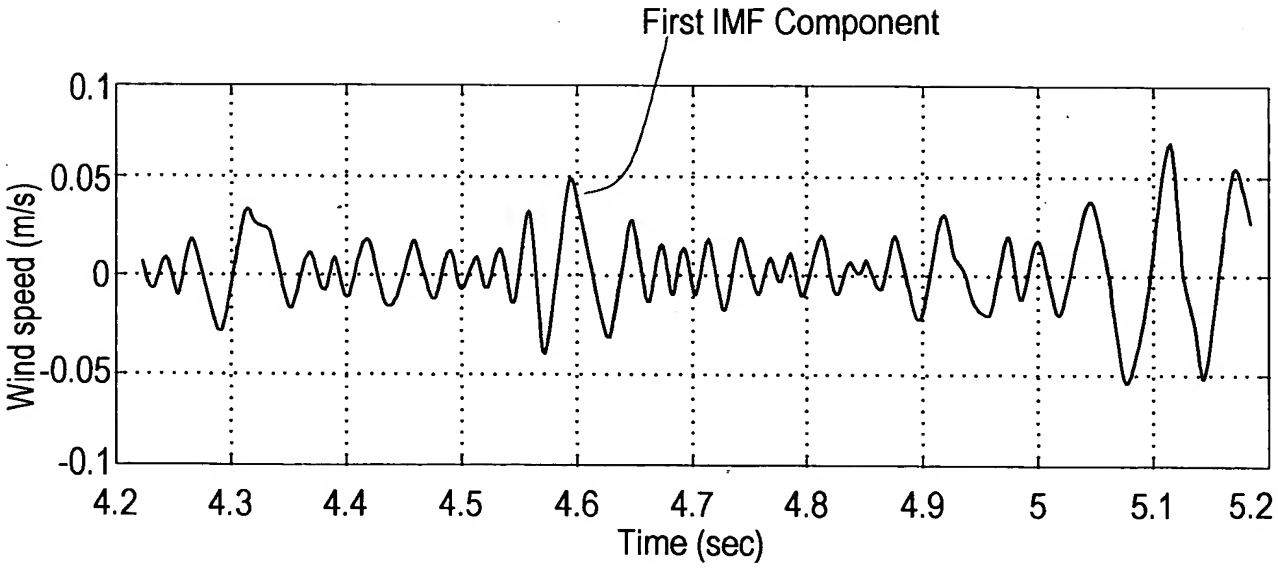
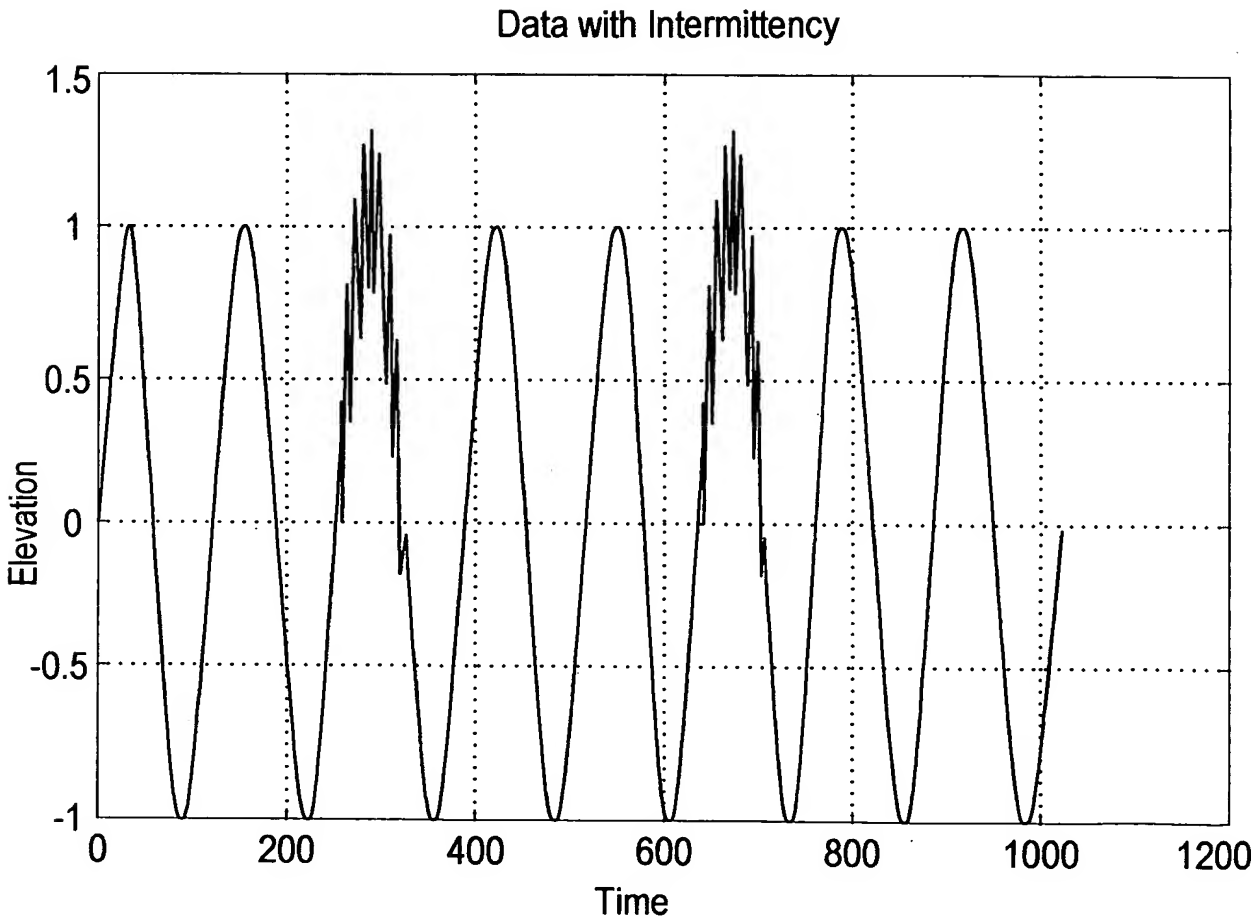

First IMF Component
0.1
0.05
0
-0.05
-0.1
Wind speed (m/s)
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
5
5.1
5.2
Time (sec)

FIG. 3(g)


Data with Intermittency
1.5
1
0.5
0
-0.5
-1
Elevation
0
200
400
600
800
1000
1200
Time

EMD-IMF without intermittency option

FIG. 3(h)

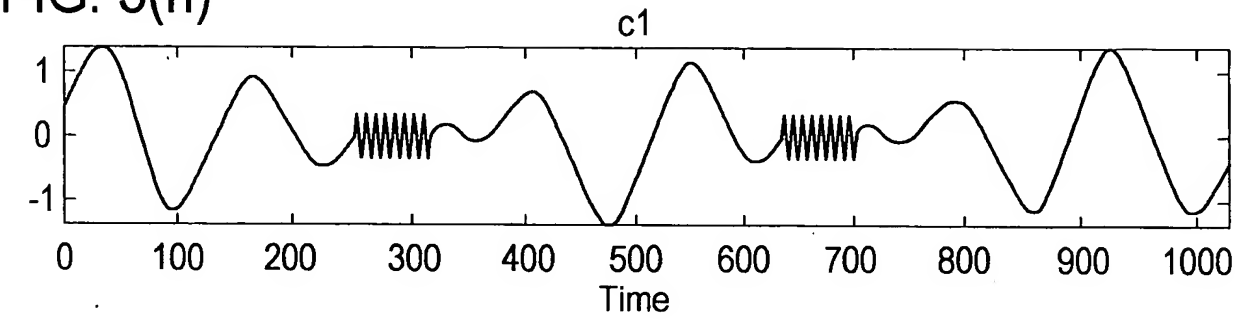


FIG. 3(i)

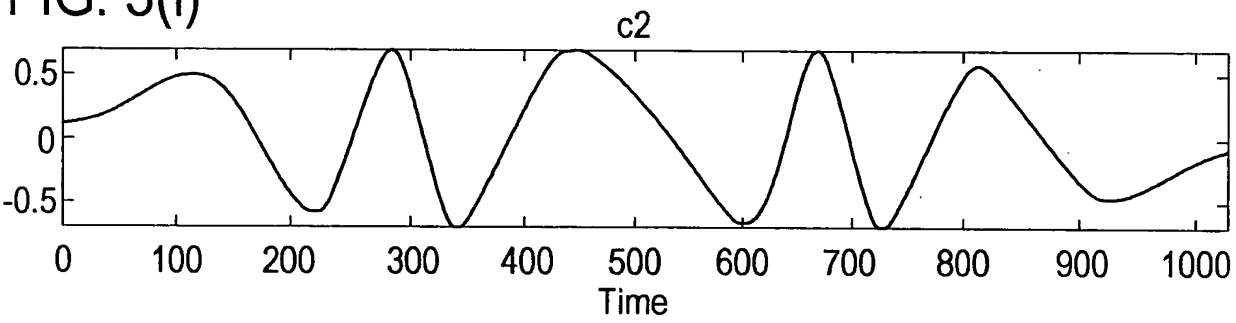


FIG. 3(j)

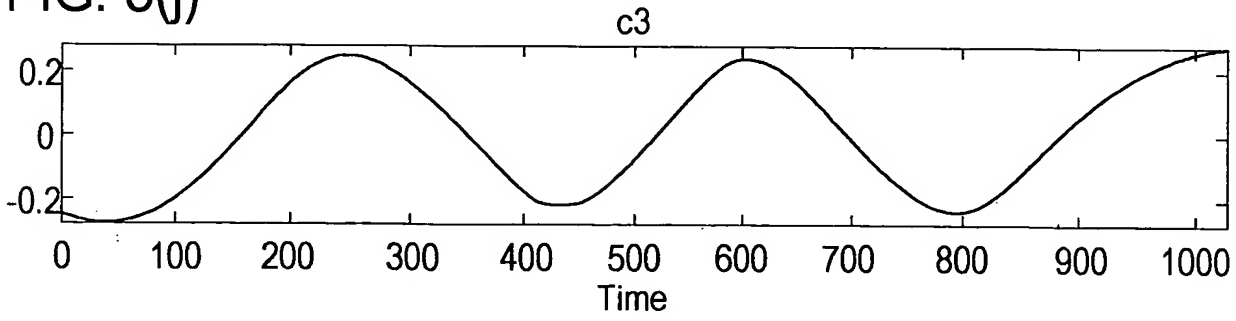


FIG. 3(k)

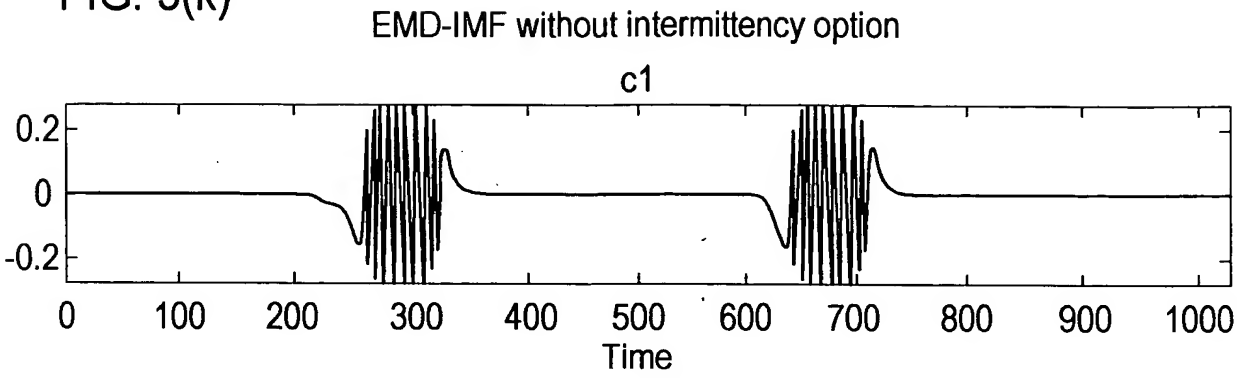


FIG. 3(l)

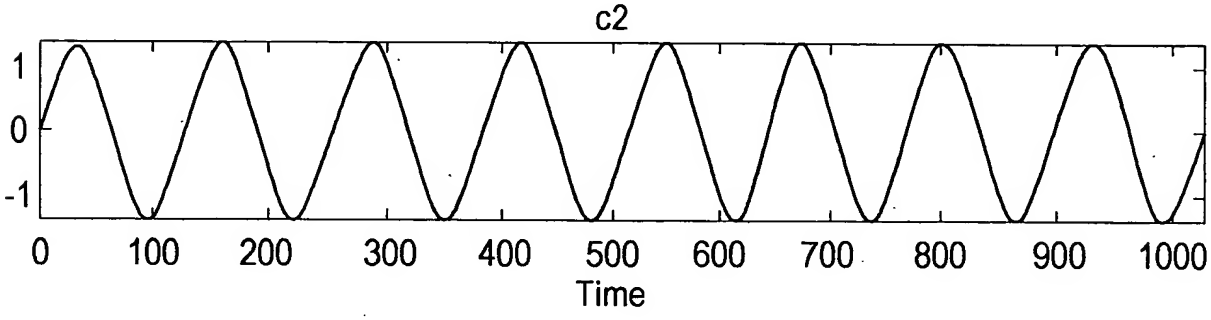


FIG. 3(m)

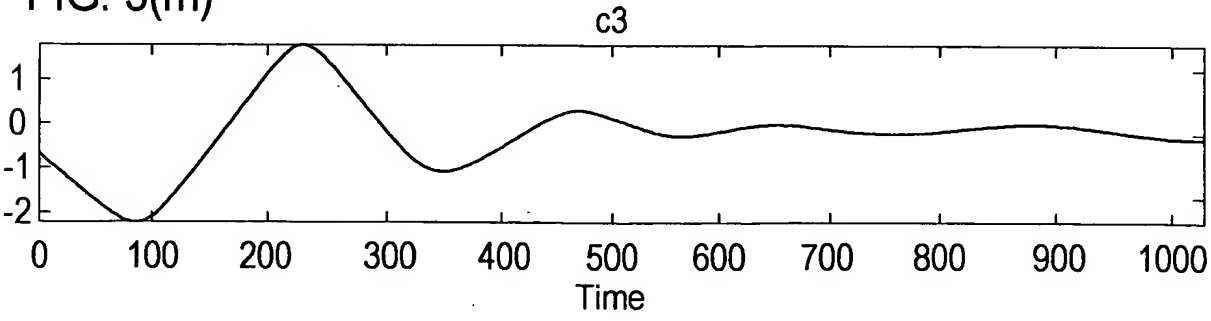


FIG. 4(a)

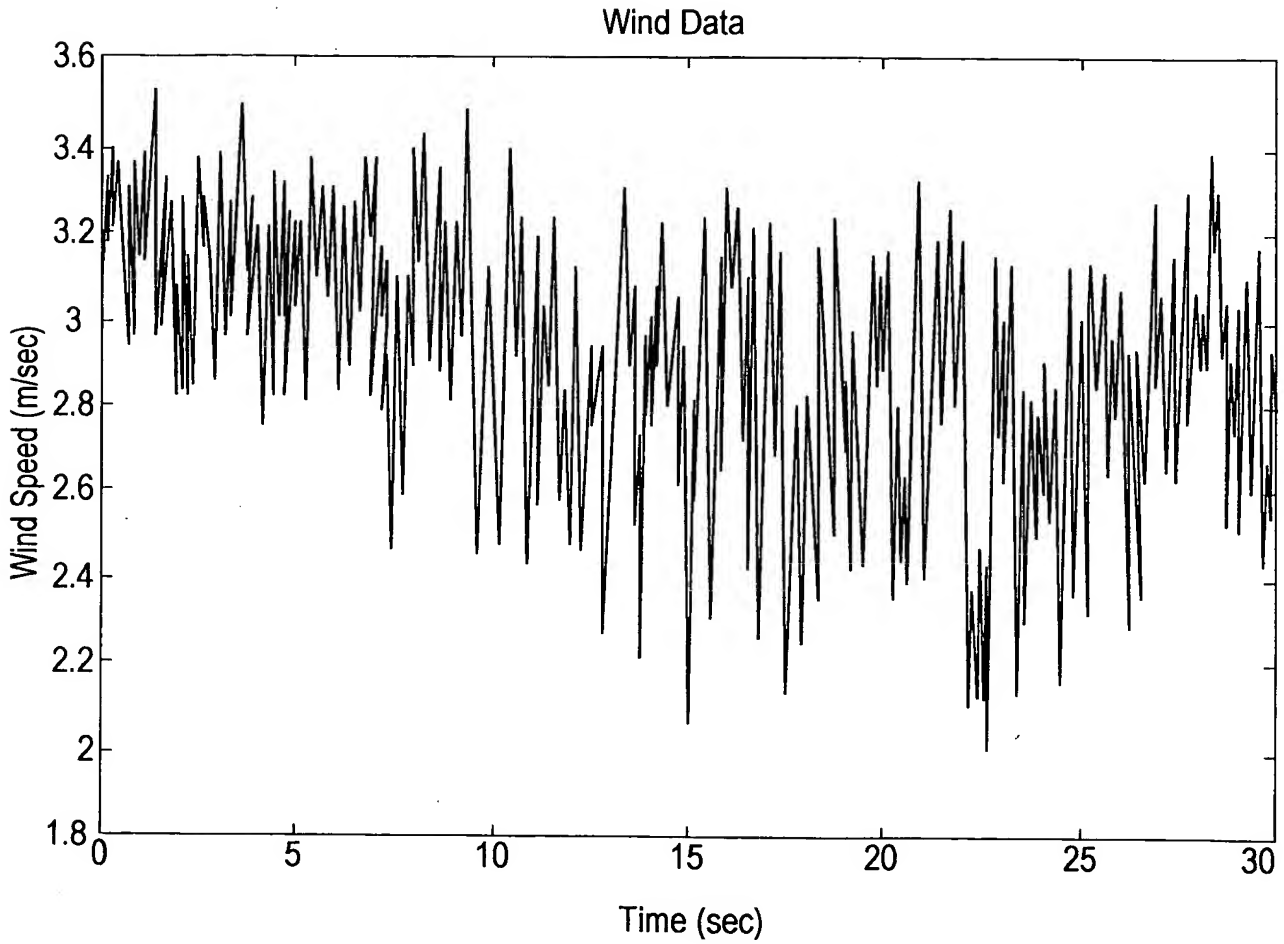

Wind Data
Wind Speed (m/sec)
Time (sec)
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
0
5
10
15
20
25
30

FIG. 4(b)

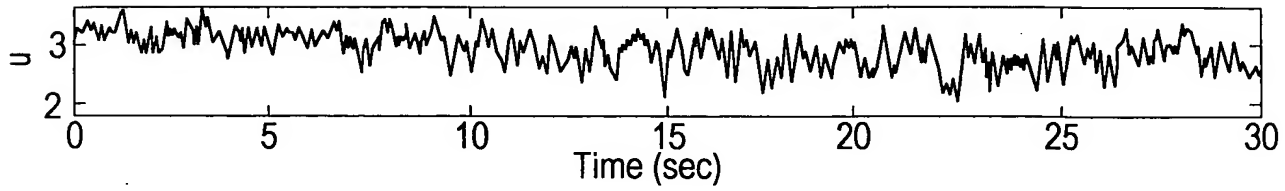


FIG. 4(c)

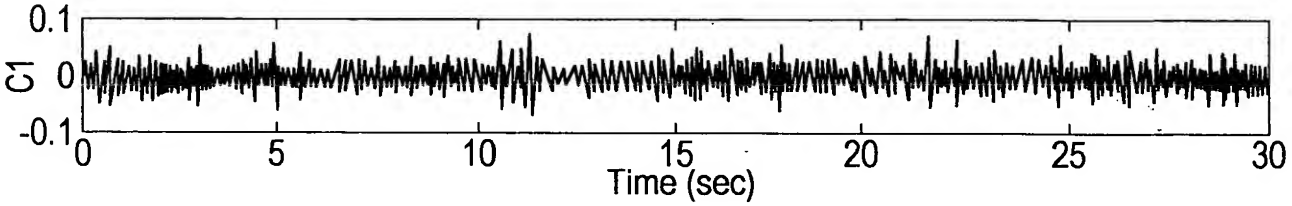


FIG. 4(d)

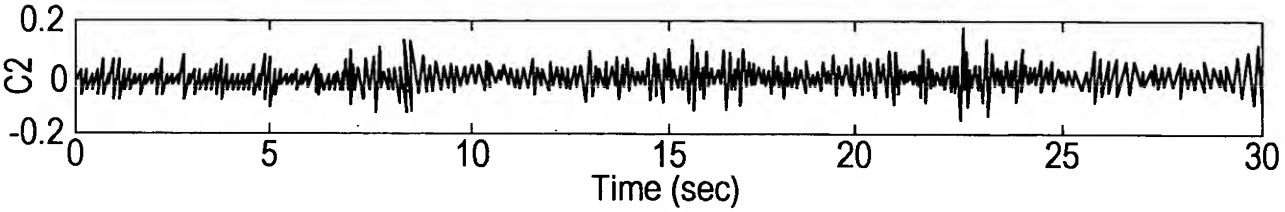


FIG. 4(e)

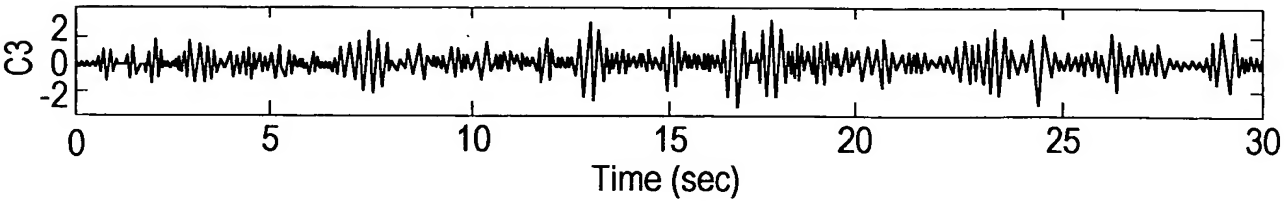


FIG. 4(f)

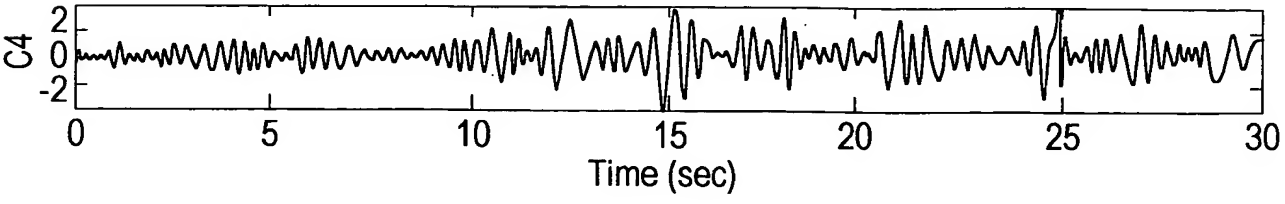


FIG. 4(g)

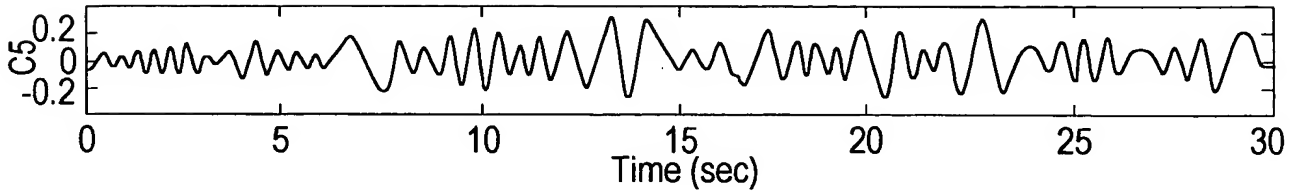


FIG. 4(h)

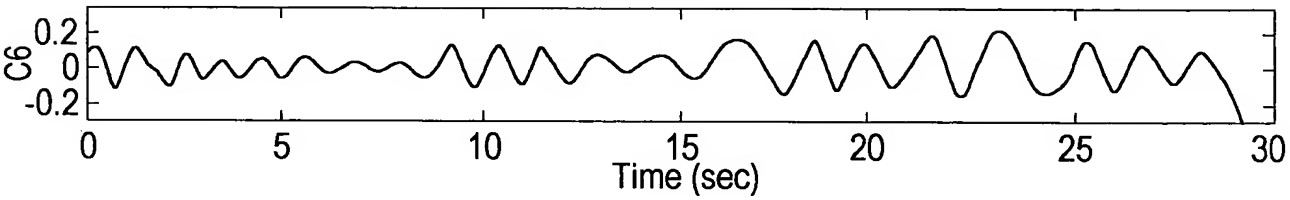


FIG. 4(i)

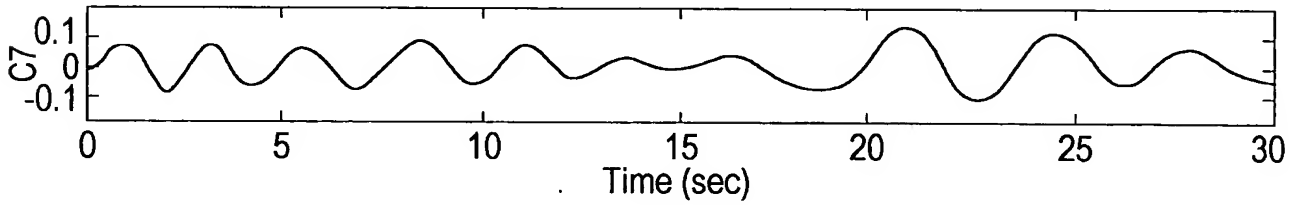


FIG. 4(j)

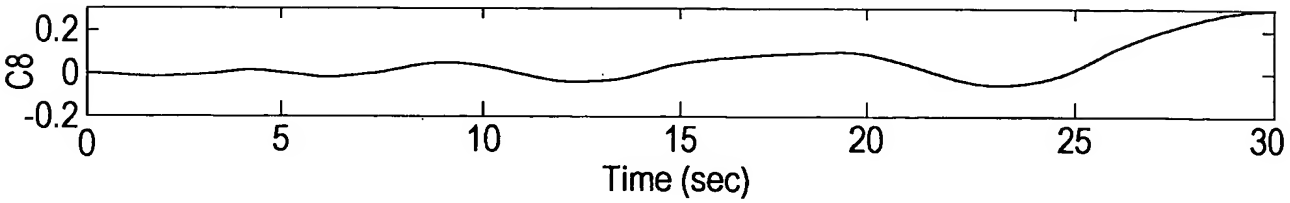


FIG. 4(k)

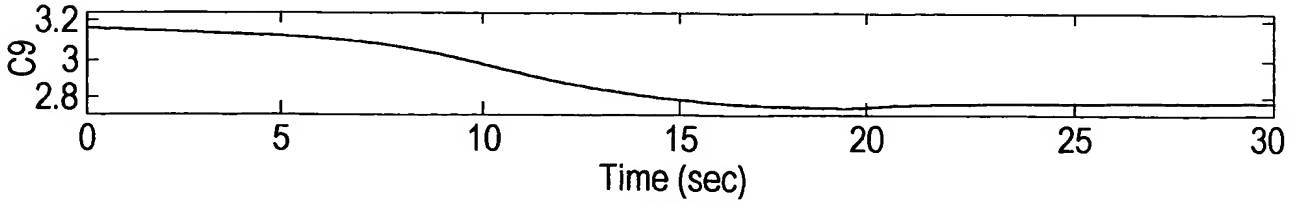


FIG. 5(a)

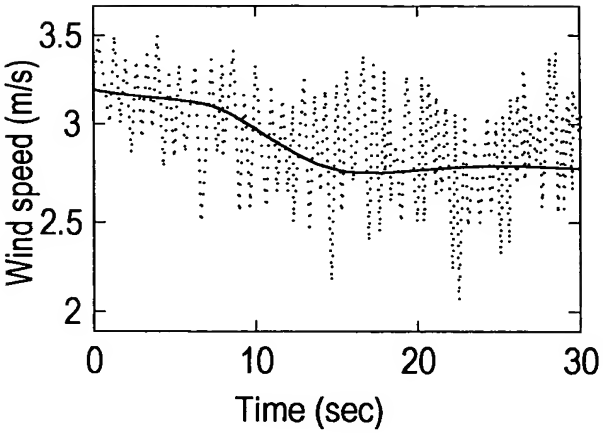


FIG. 5(b)

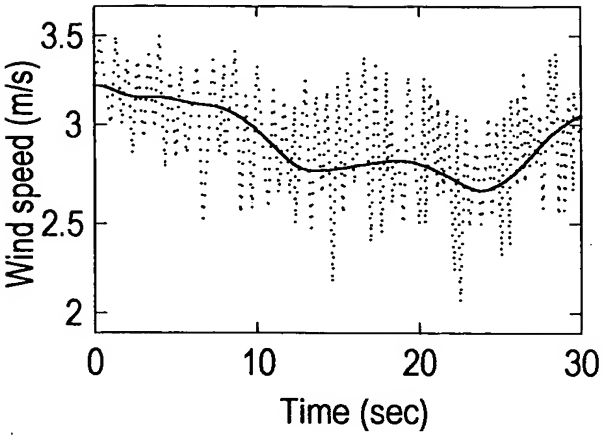


FIG. 5(c)

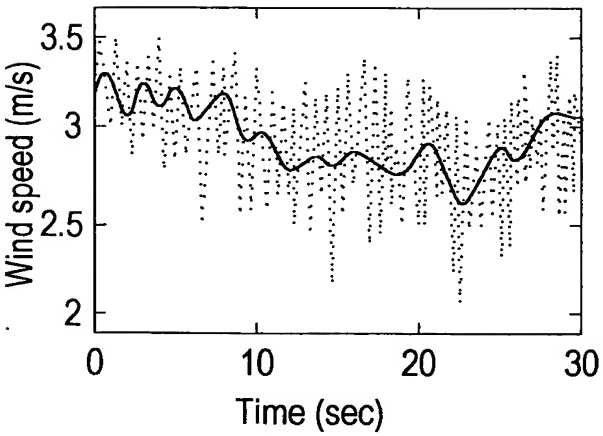


FIG. 5(d)

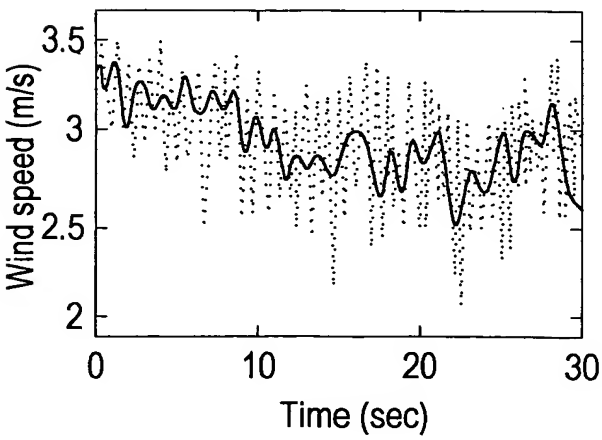


FIG. 5(e)

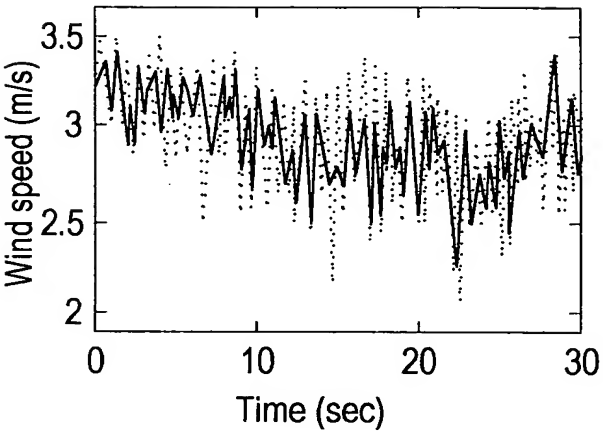


FIG. 5(f)

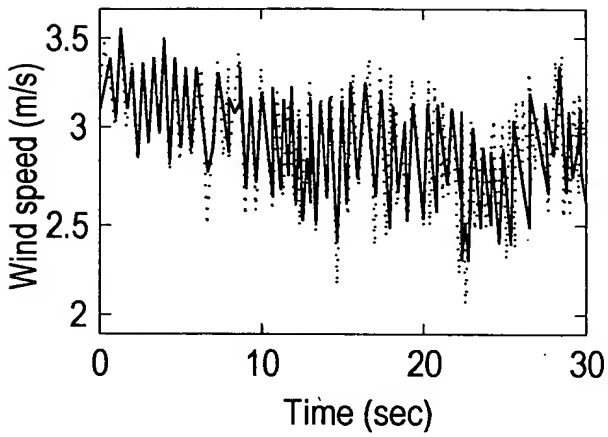


FIG. 5(g)

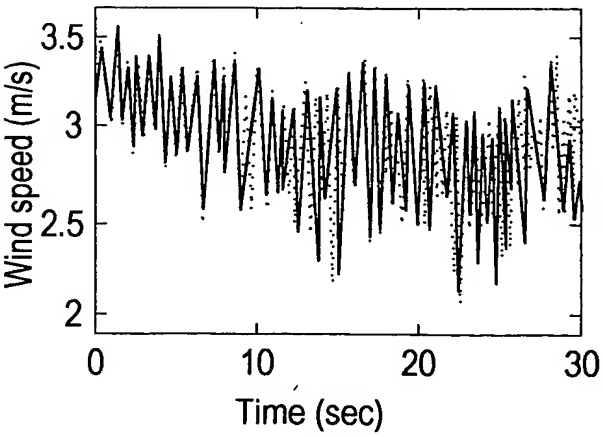


FIG. 5(h)

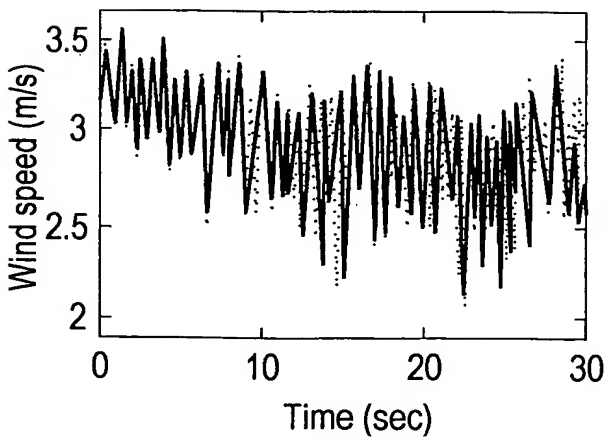


FIG. 5(i)

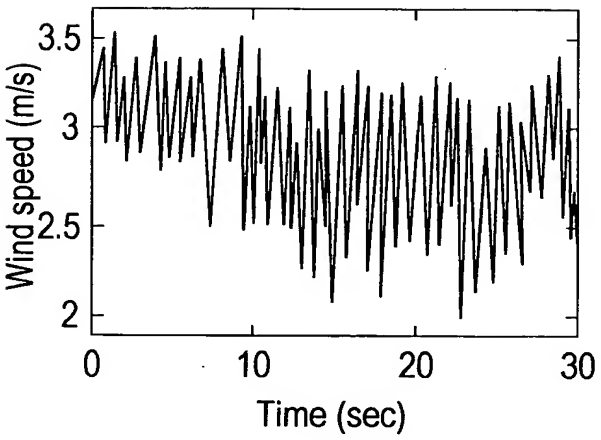

Wind speed (m/s)
3.5
3
2.5
2
0
10
20
30
Time (sec)

FIG. 5(j)

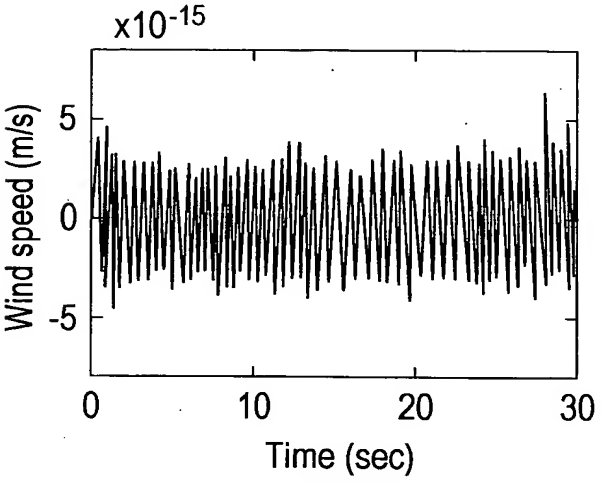

x10-15
Wind speed (m/s)
5
0
-5
0
10
20
30
Time (sec)

FIG. 6(a)

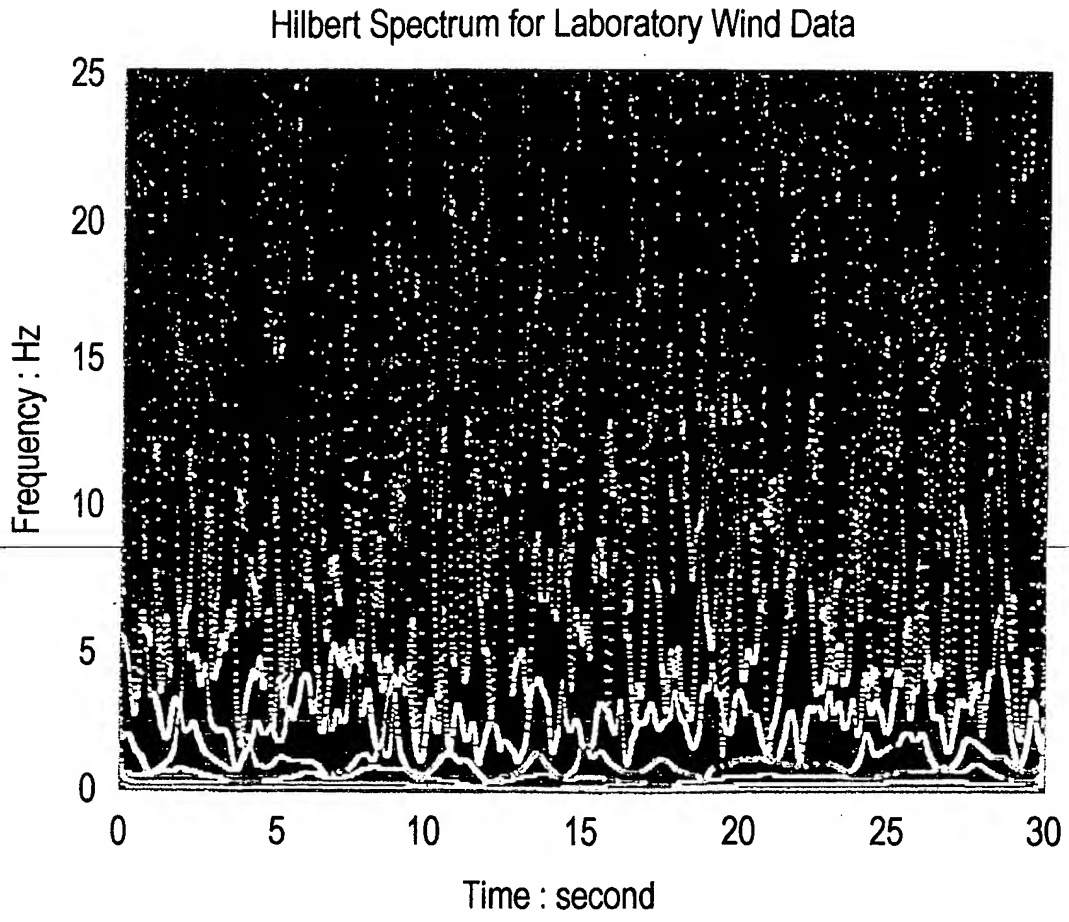

Hilbert Spectrum for Laboratory Wind Data
Frequency : Hz
25
20
15
10
5
0
0
5
10
15
20
25
30
Time : second

FIG. 6(b)

Wavelet Spectrum for Laboratory Wind Data

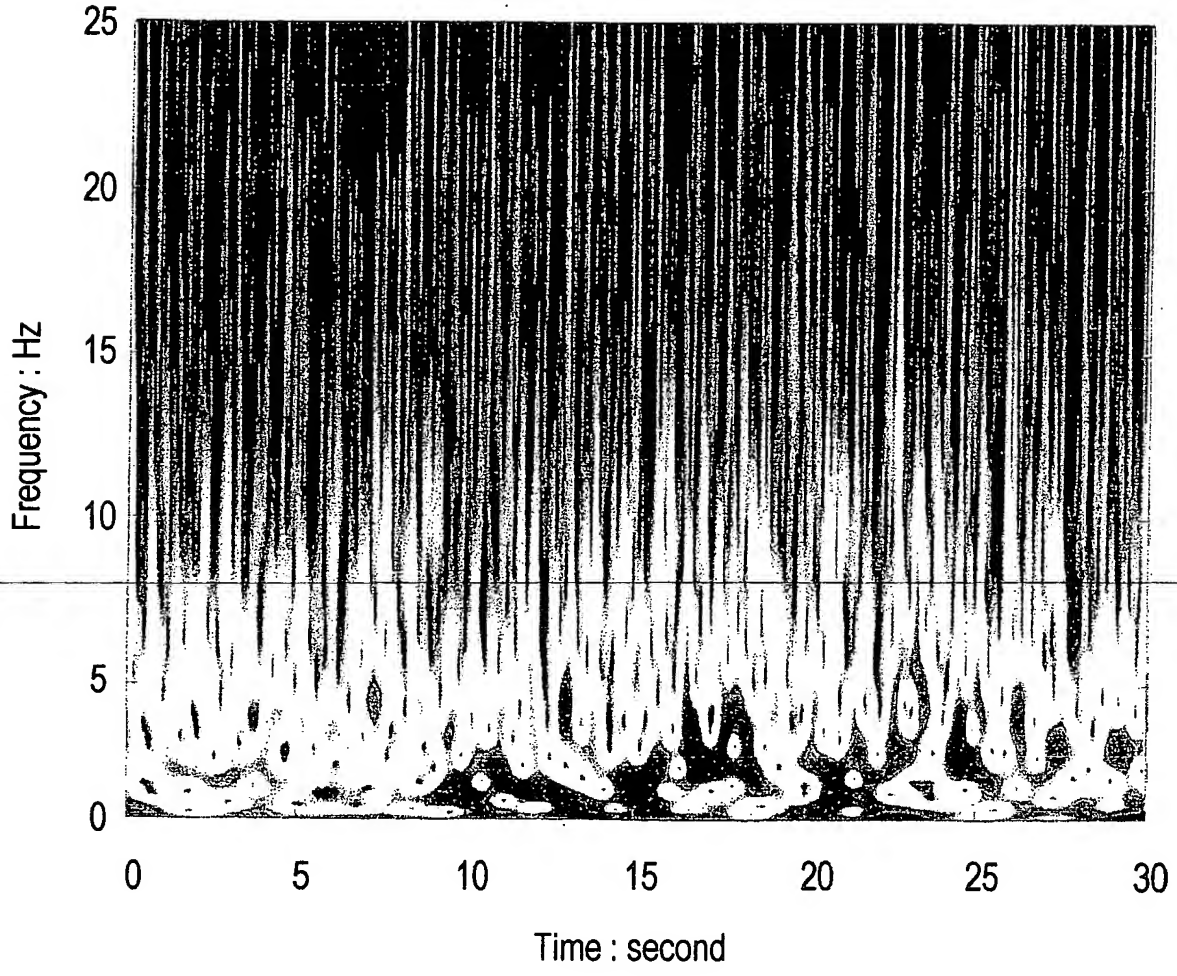


FIG. 6(c)

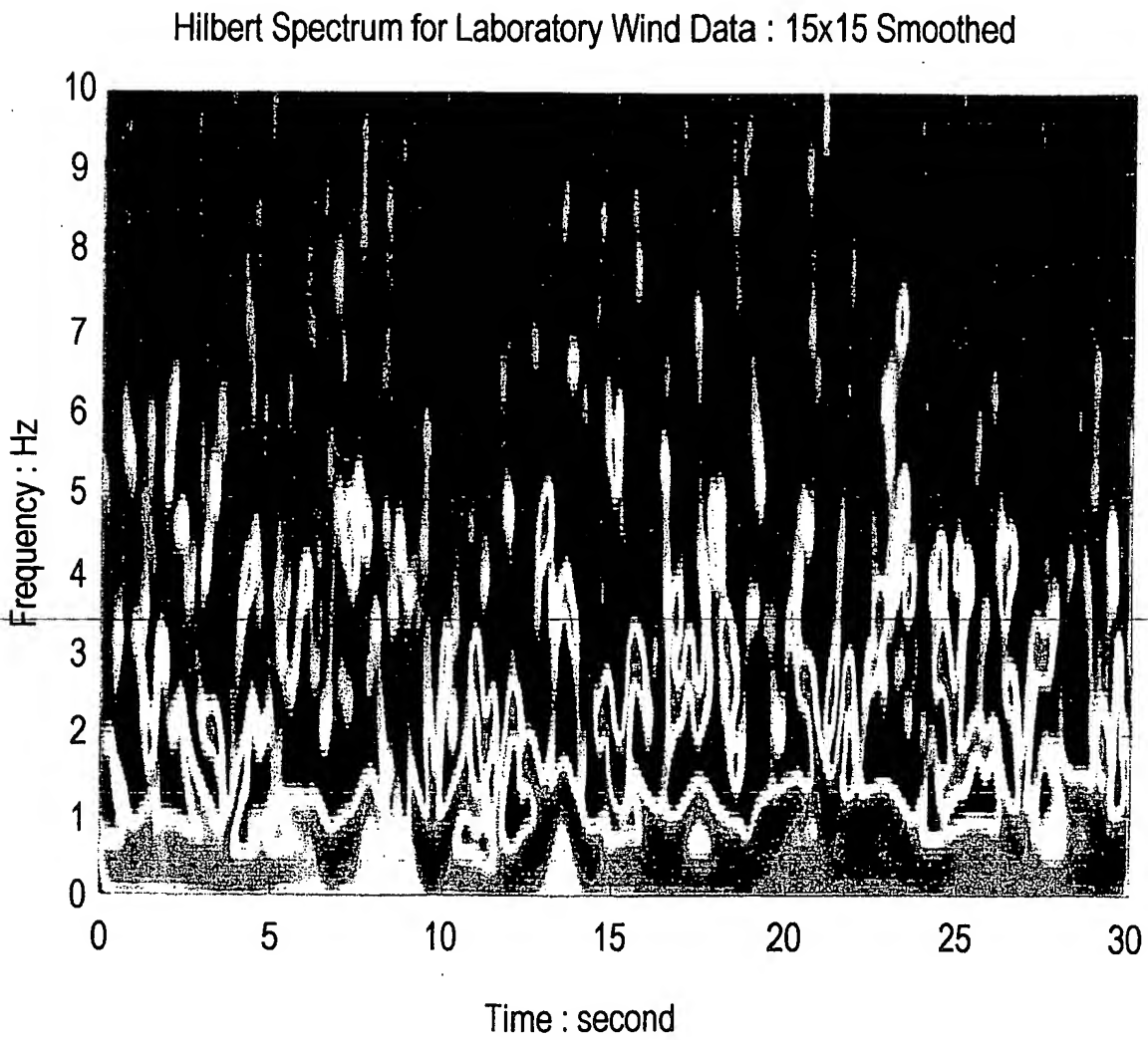

Hilbert Spectrum for Laboratory Wind Data : 15x15 Smoothed
Frequency : Hz
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25
30
Time : second

FIG. 7

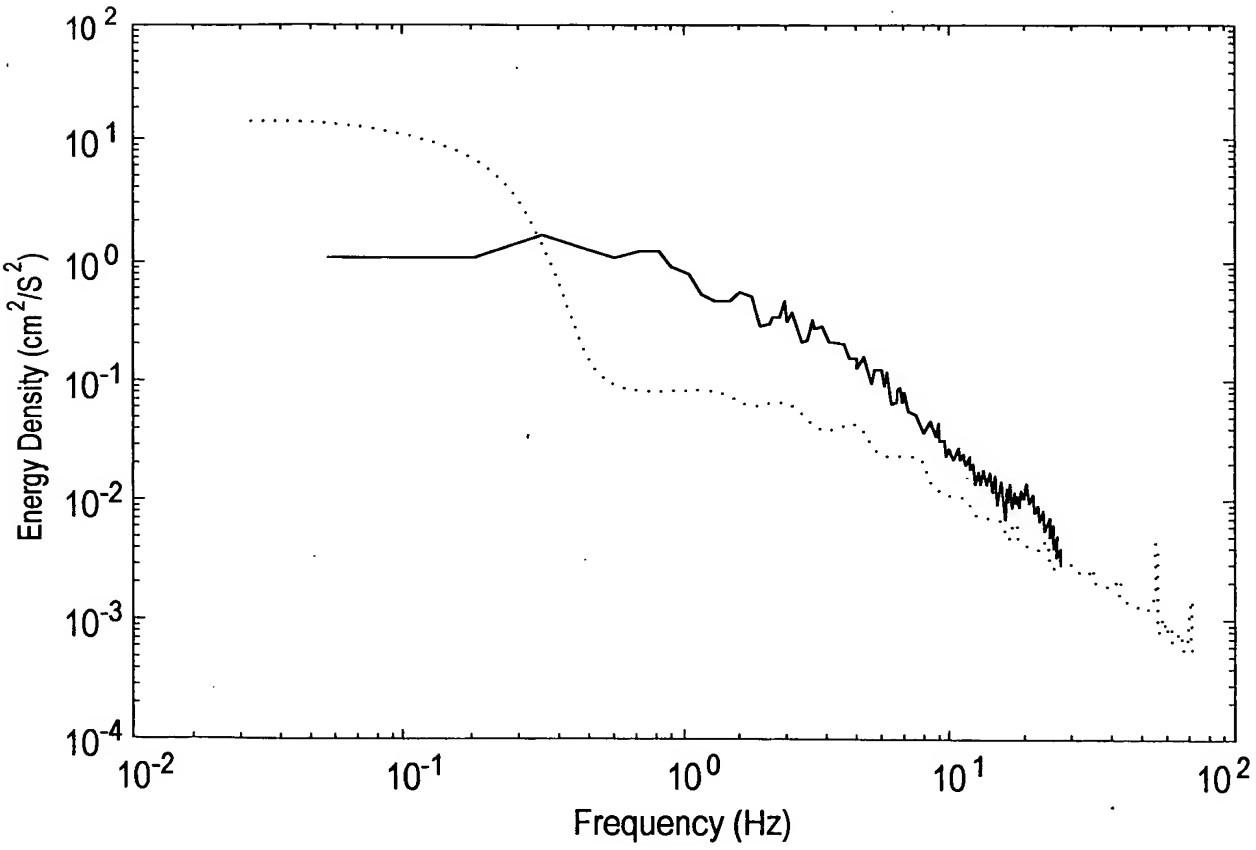

Energy Density (cm²/S²)
Frequency (Hz)
10²
10¹
10⁰
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻²
10⁻¹
10⁰
10¹
10²

FIG. 8(a)

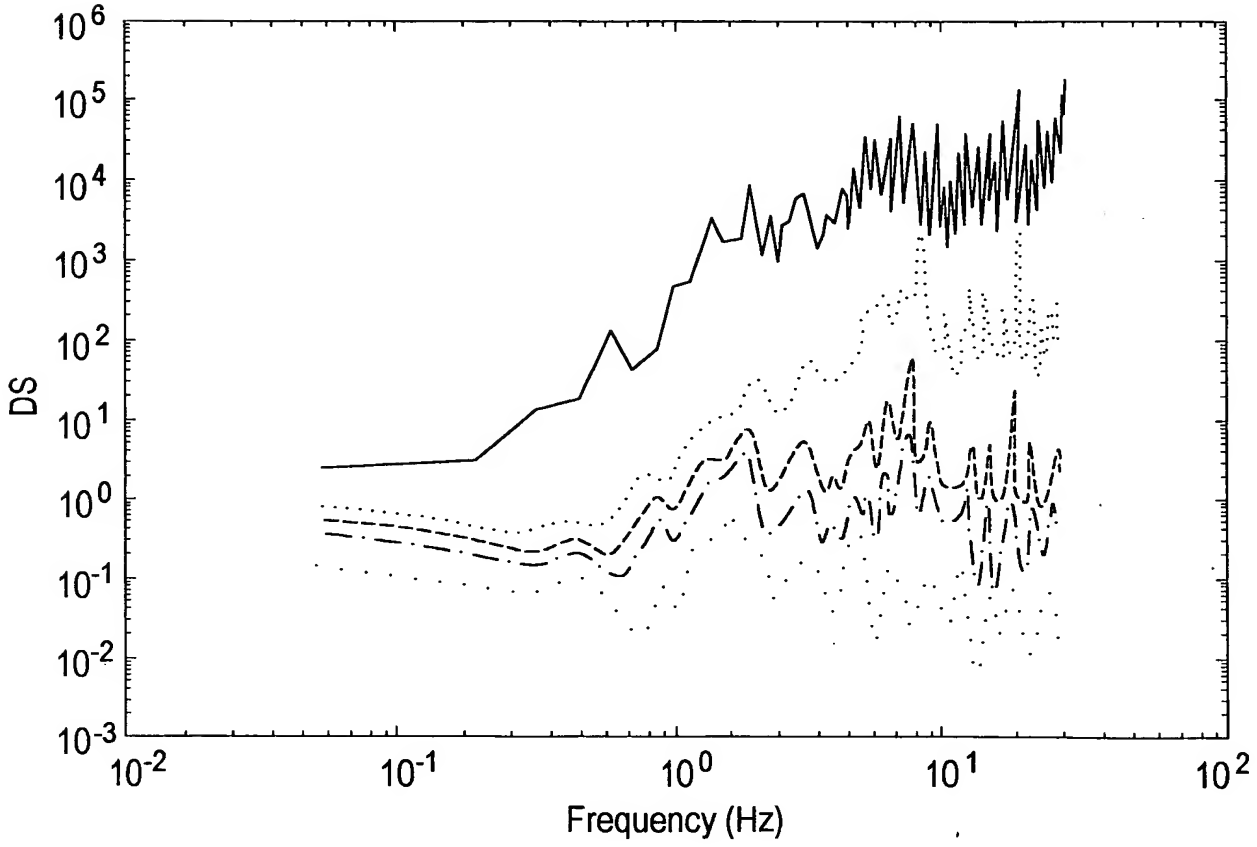

DS
10^6
10^5
10^4
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-2}
10^{-1}
10^0
10^1
10^2
Frequency (Hz)

FIG. 8(b)

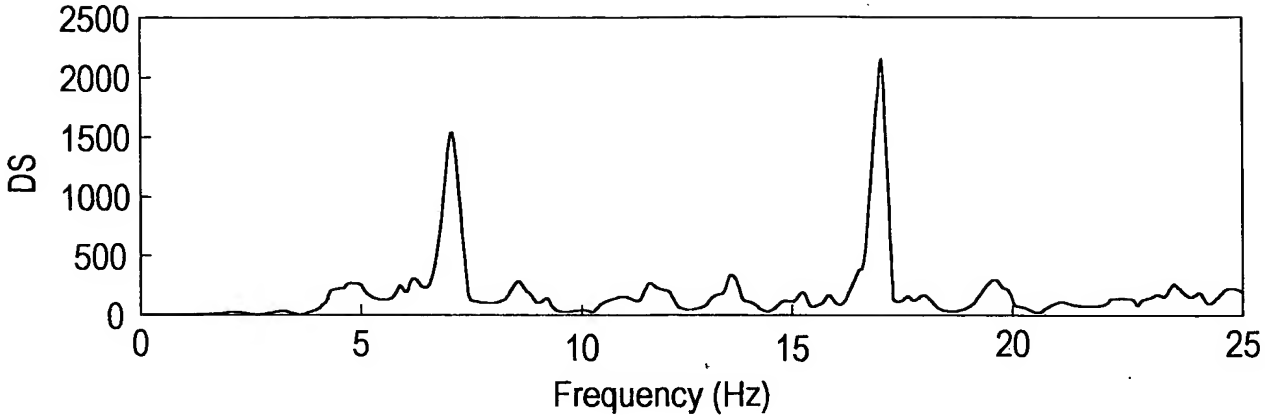
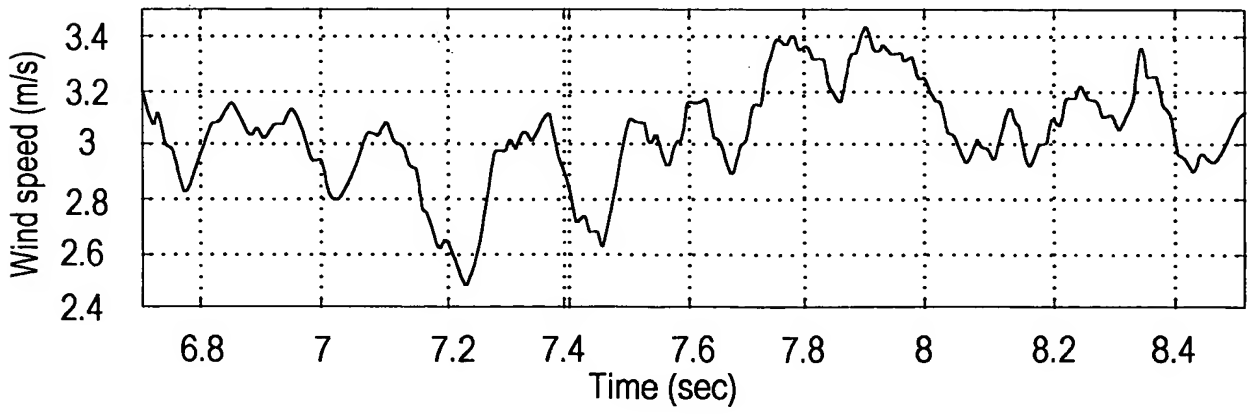

2500
2000
1500
1000
500
0
DS
0
5
10
15
20
25
Frequency (Hz)

FIG. 8(c)


3.4
3.2
3
2.8
2.6
2.4
Wind speed (m/s)
6.8
7
7.2
7.4
7.6
7.8
8
8.2
8.4
Time (sec)

PULMONARY ARTERIAL PRESSURE OF RAT (24 HR.)

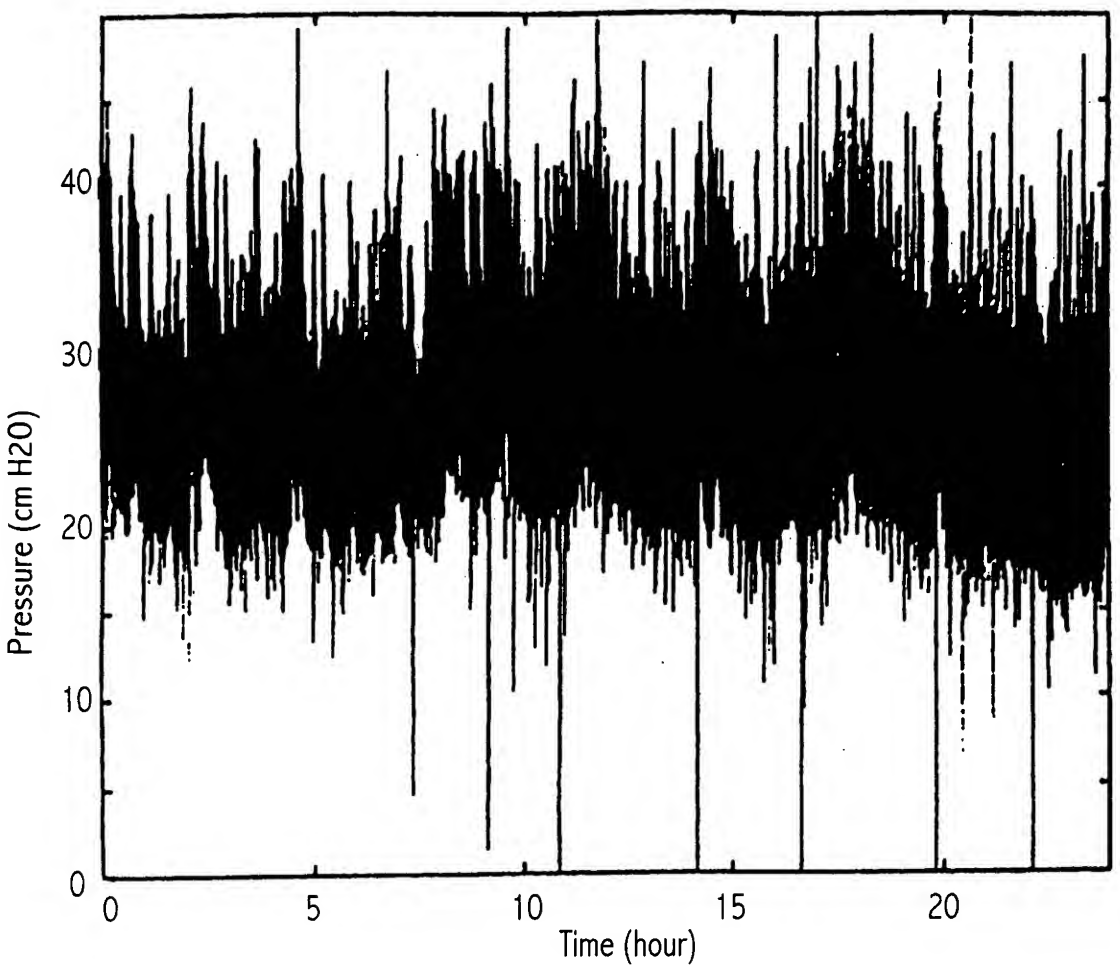


FIG. 9(a)

20020820 256202

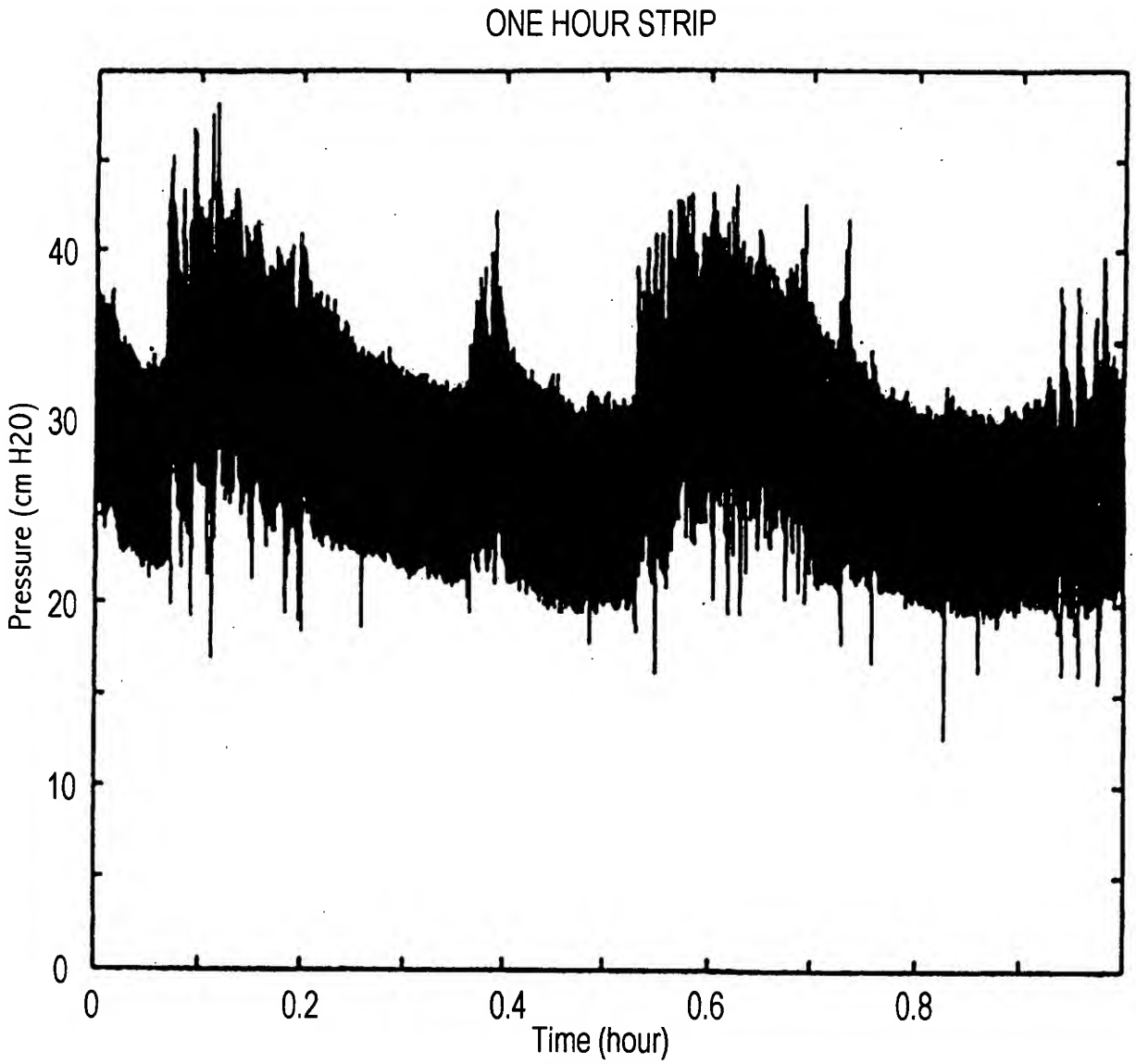


FIG. 9(b)

FIG. 9(c)

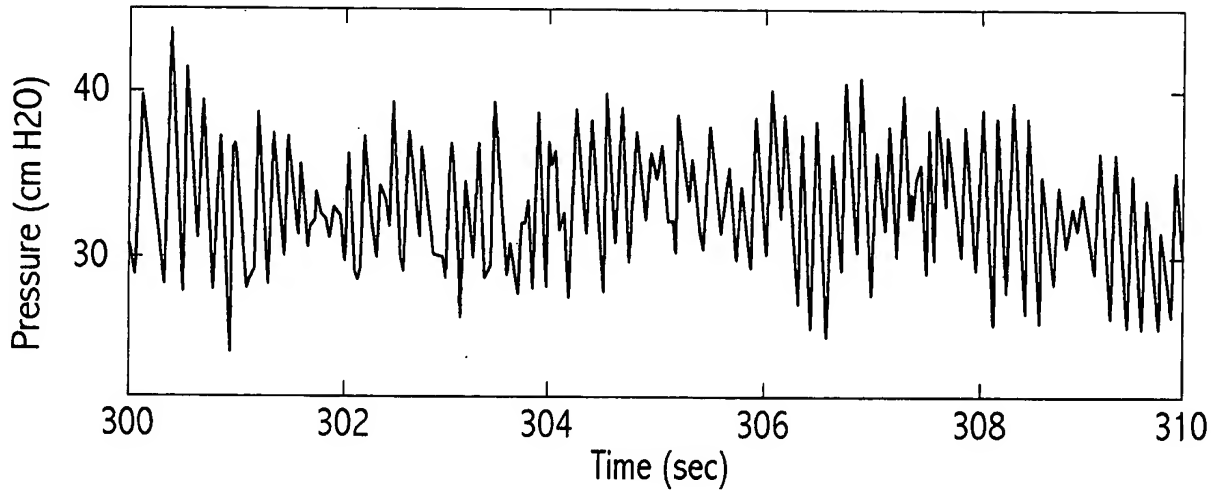
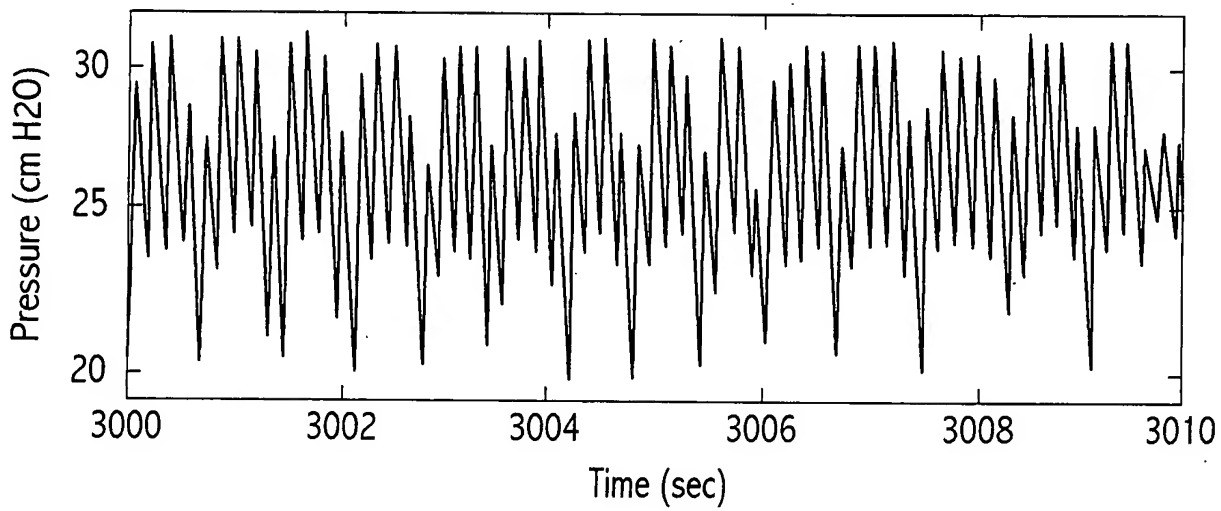

Pressure (cm H2O)
40
30
300
302
304
306
308
310
Time (sec)

FIG. 9(d)


Pressure (cm H2O)
30
25
20
3000
3002
3004
3006
3008
3010
Time (sec)

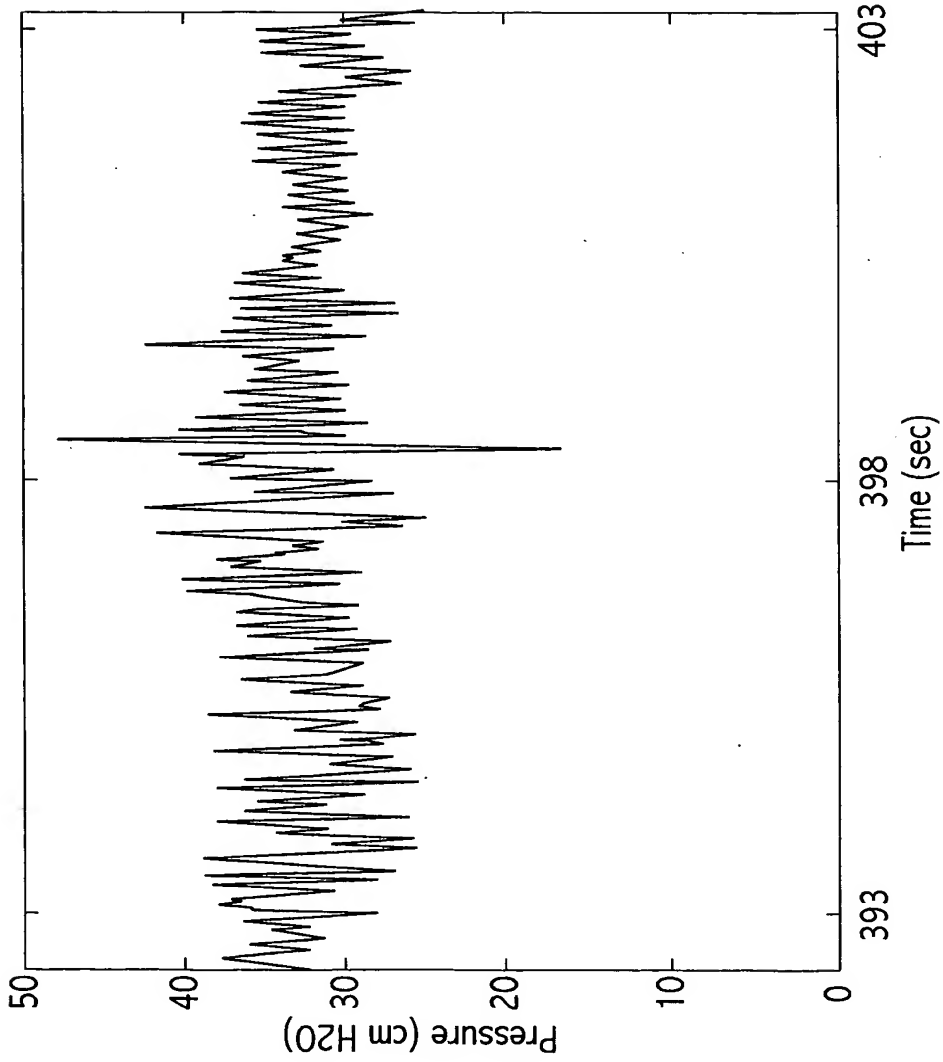


FIG. 9(e)

90E720" 2962097

FIG. 9(f)

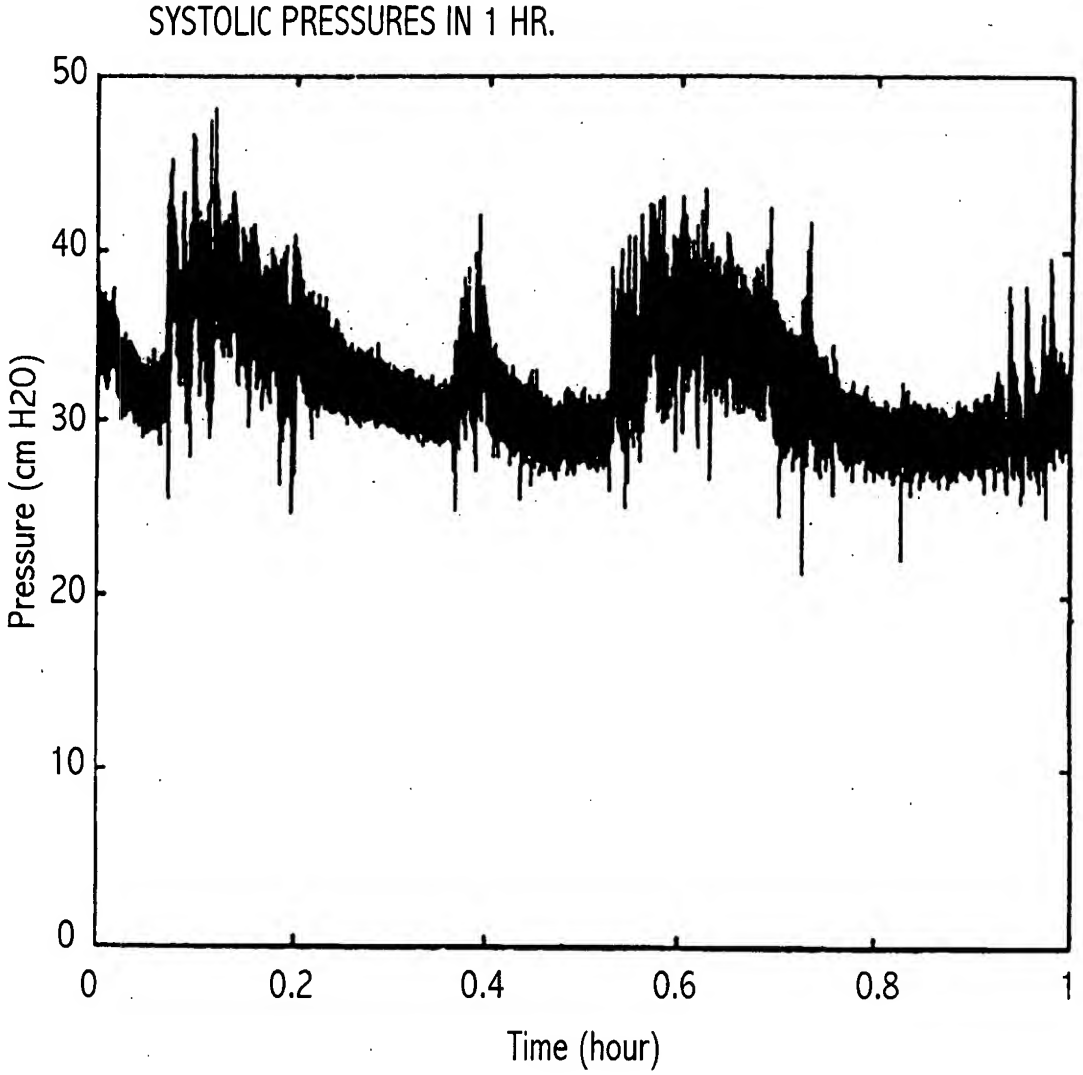
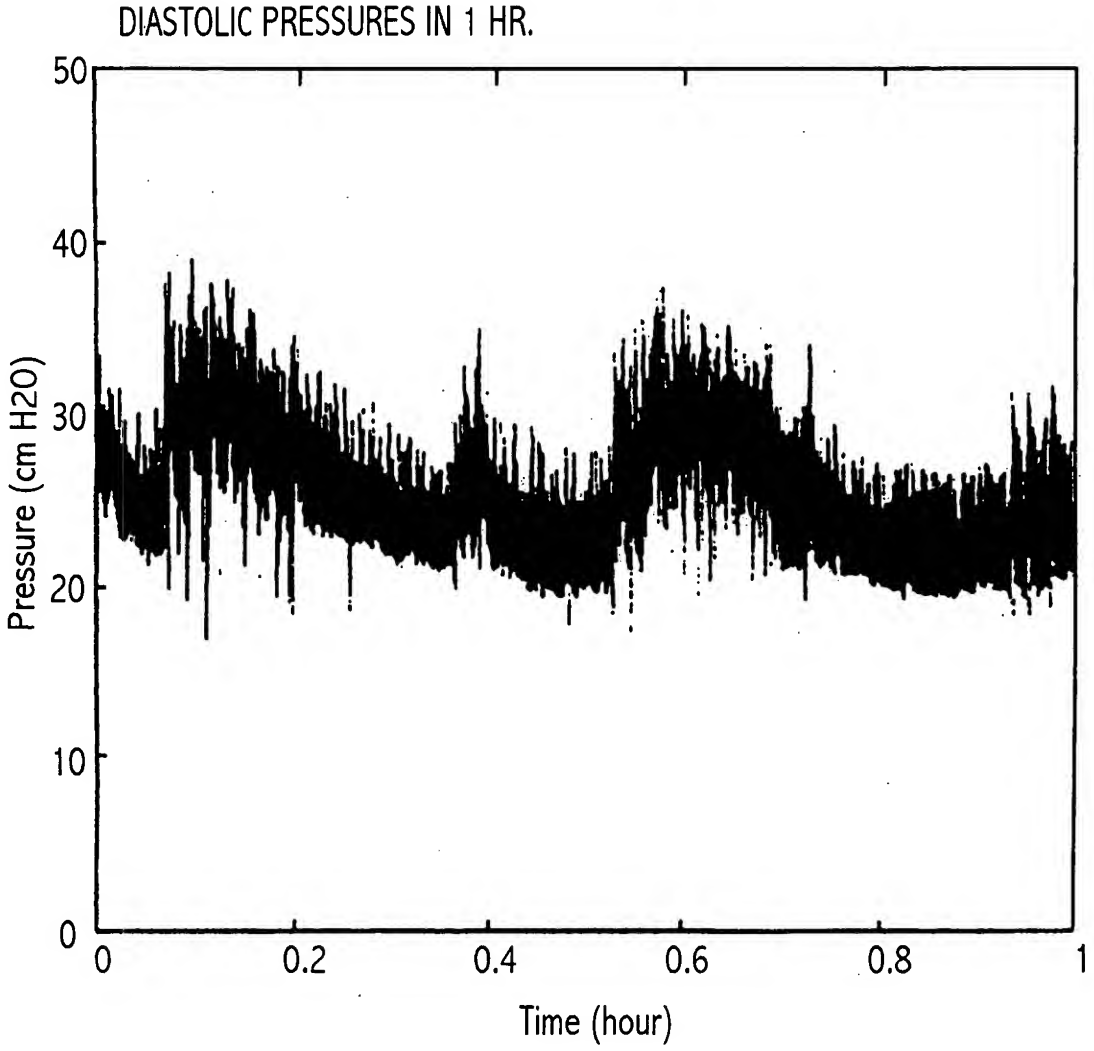


FIG. 9(g)


DIASTOLIC PRESSURES IN 1 HR.
Pressure (cm H20)
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1
Time (hour)

3DET20" 2S6E2001

FIG. 10(a)

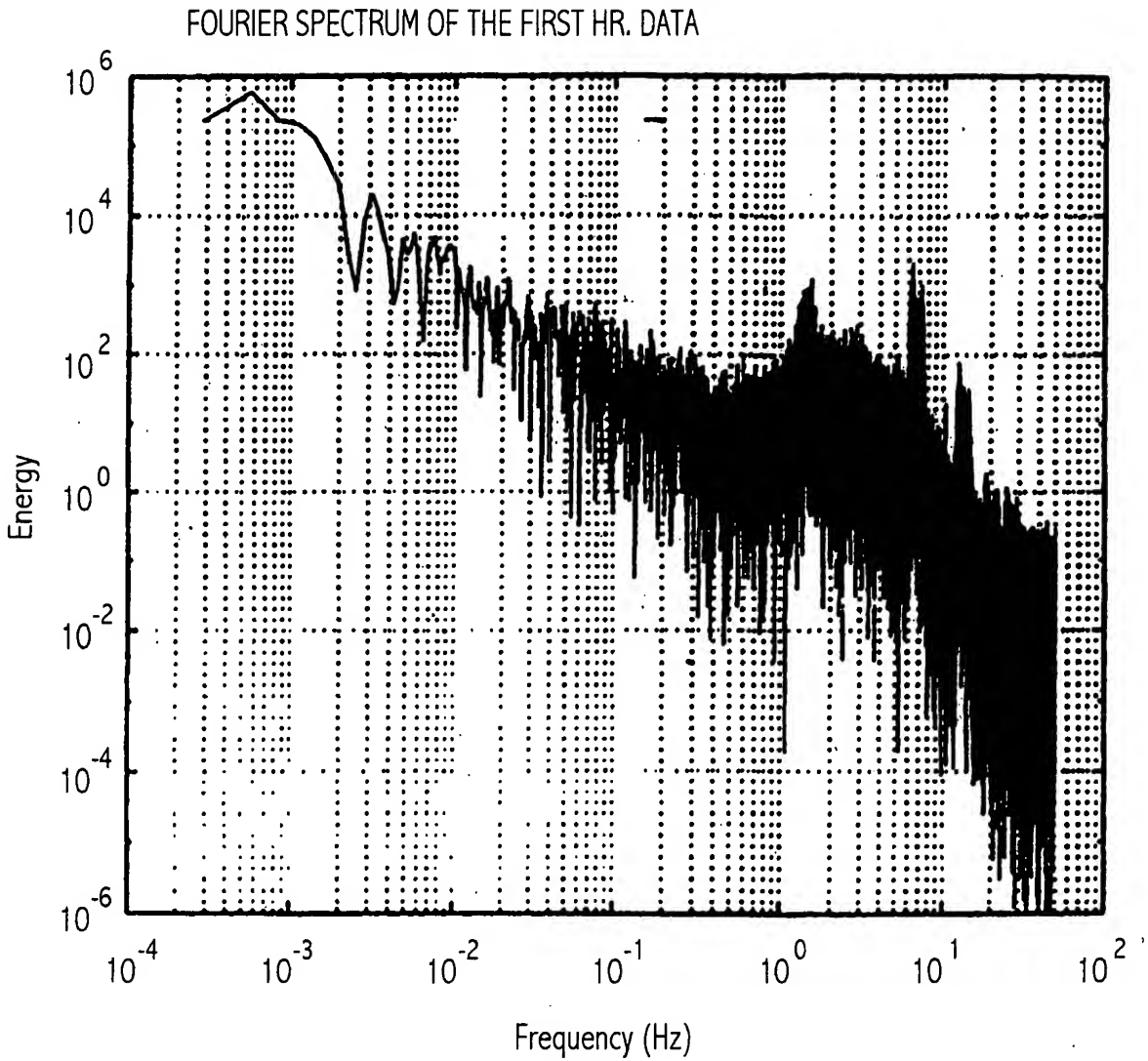


FIG. 10(b)

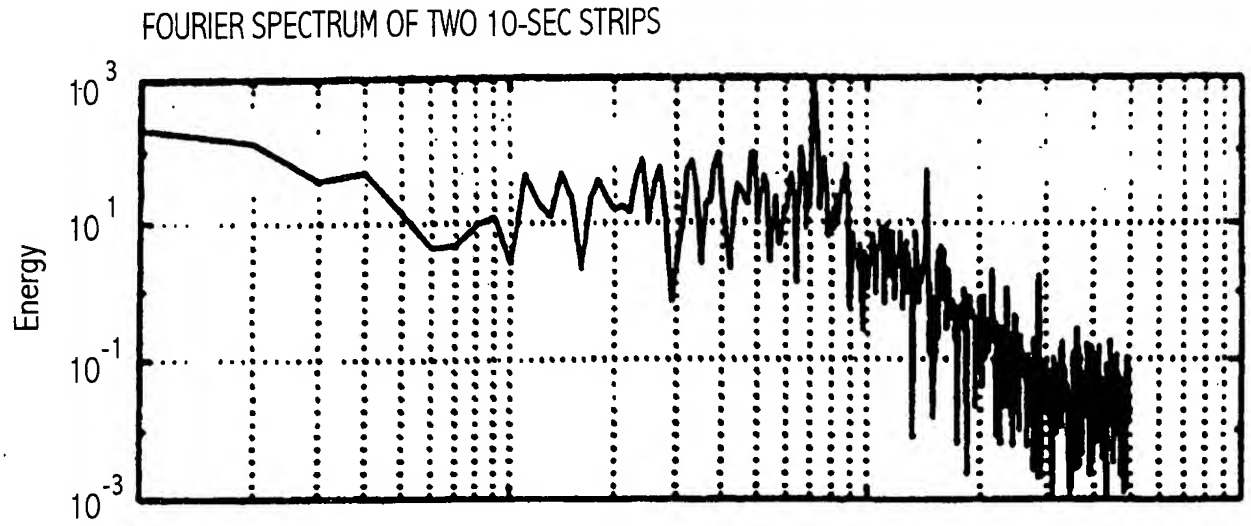


FIG. 10(c)

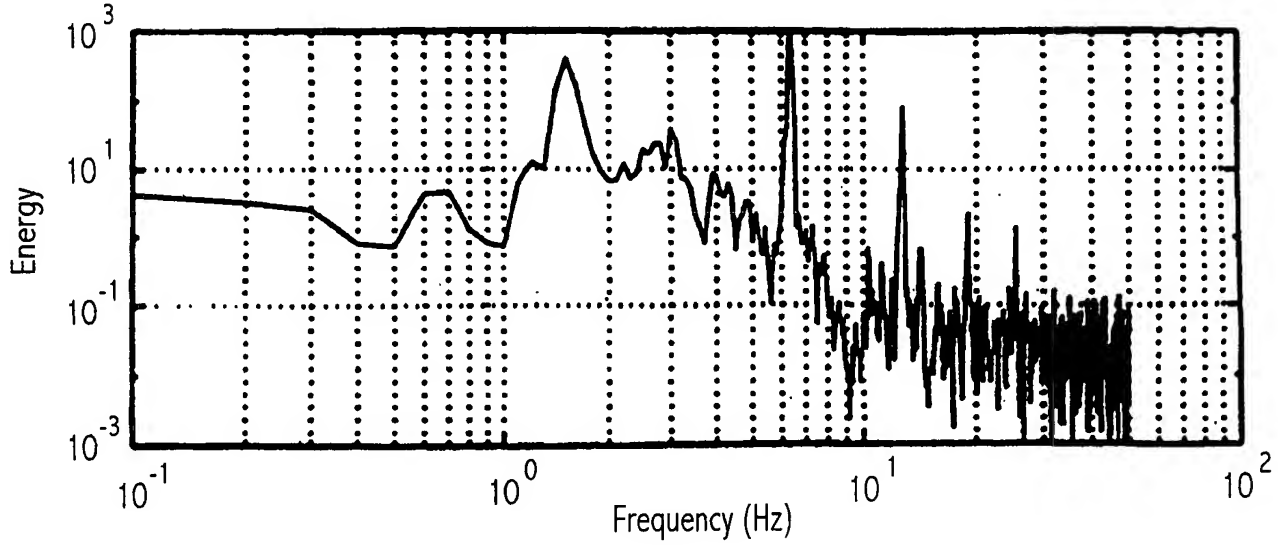
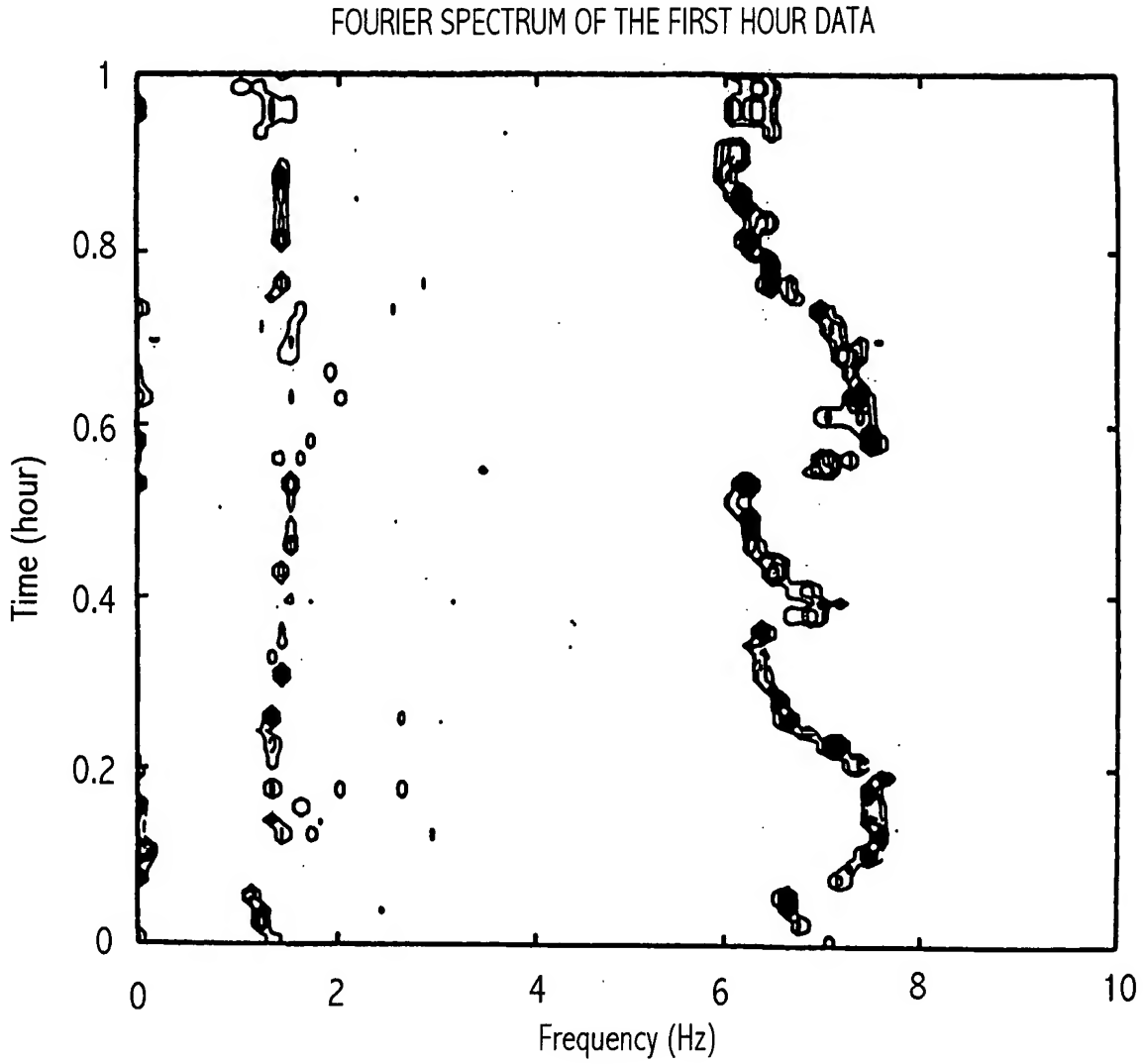


FIG. 10(d)


FOURIER SPECTRUM OF THE FIRST HOUR DATA
Time (hour)
Frequency (Hz)
0
0.2
0.4
0.6
0.8
1
0
2
4
6
8
10

20:20 2562007

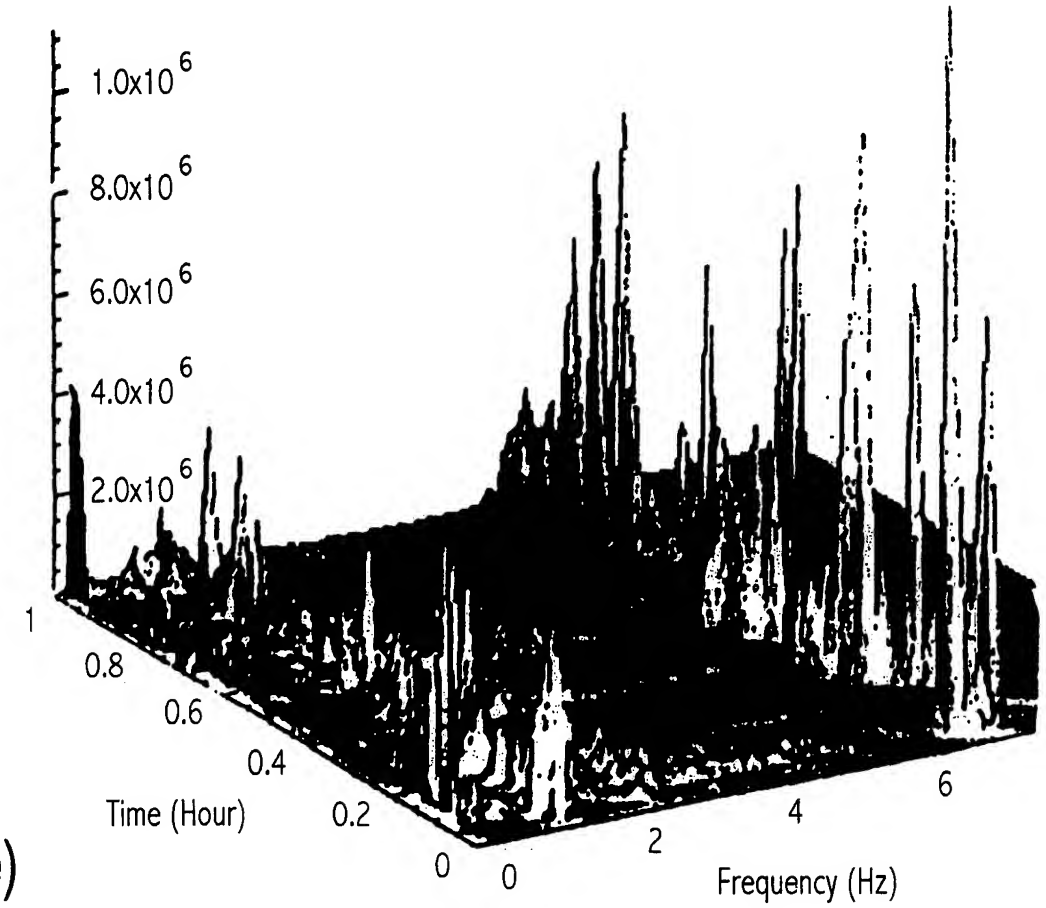


FIG. 10(e)

202T20" 2566200T

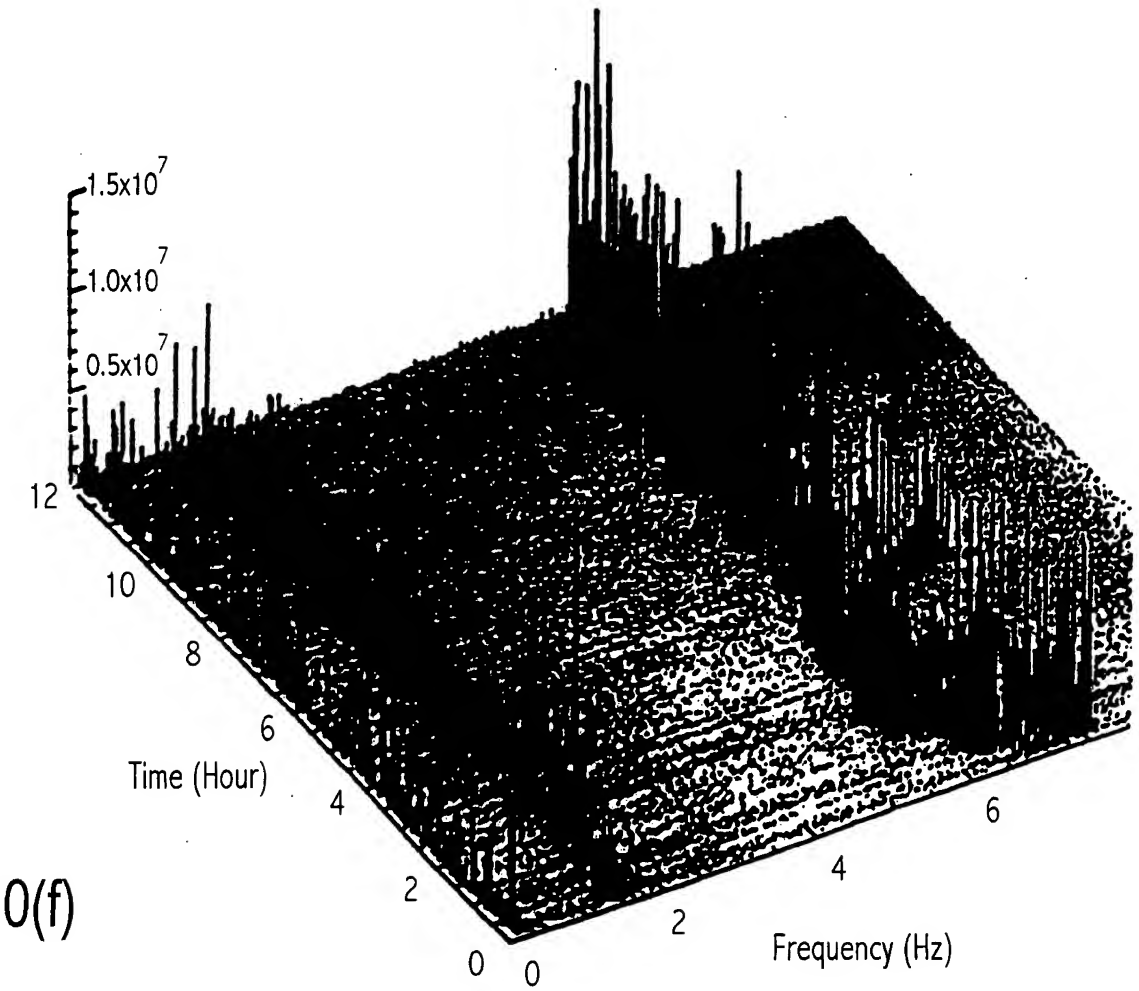


FIG. 10(f)

20020729 2962001

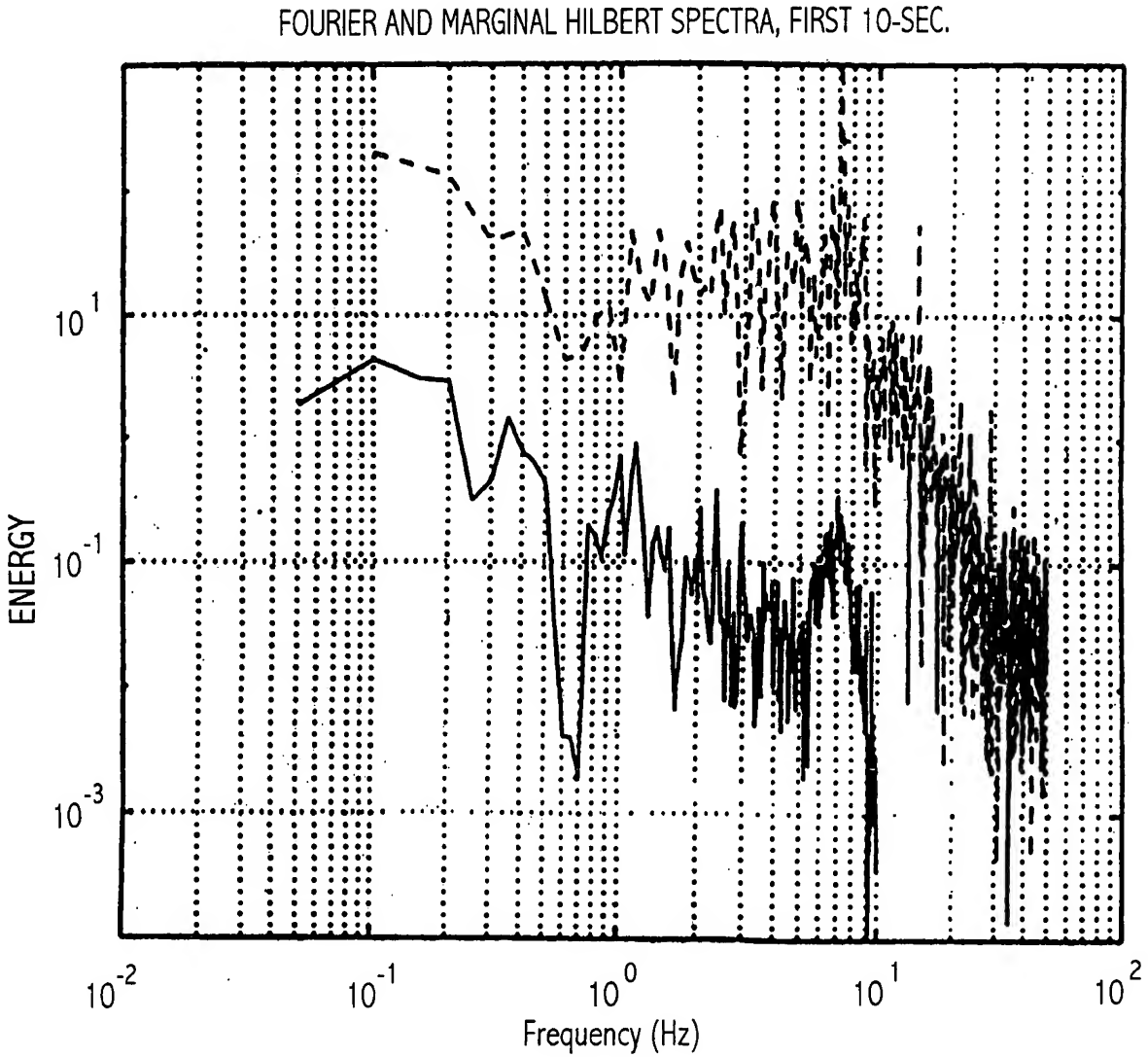


FIG. 10(g)

20070129 2362007

FIG. 11(a)

FIG. 11(b)

FIG. 11(c)

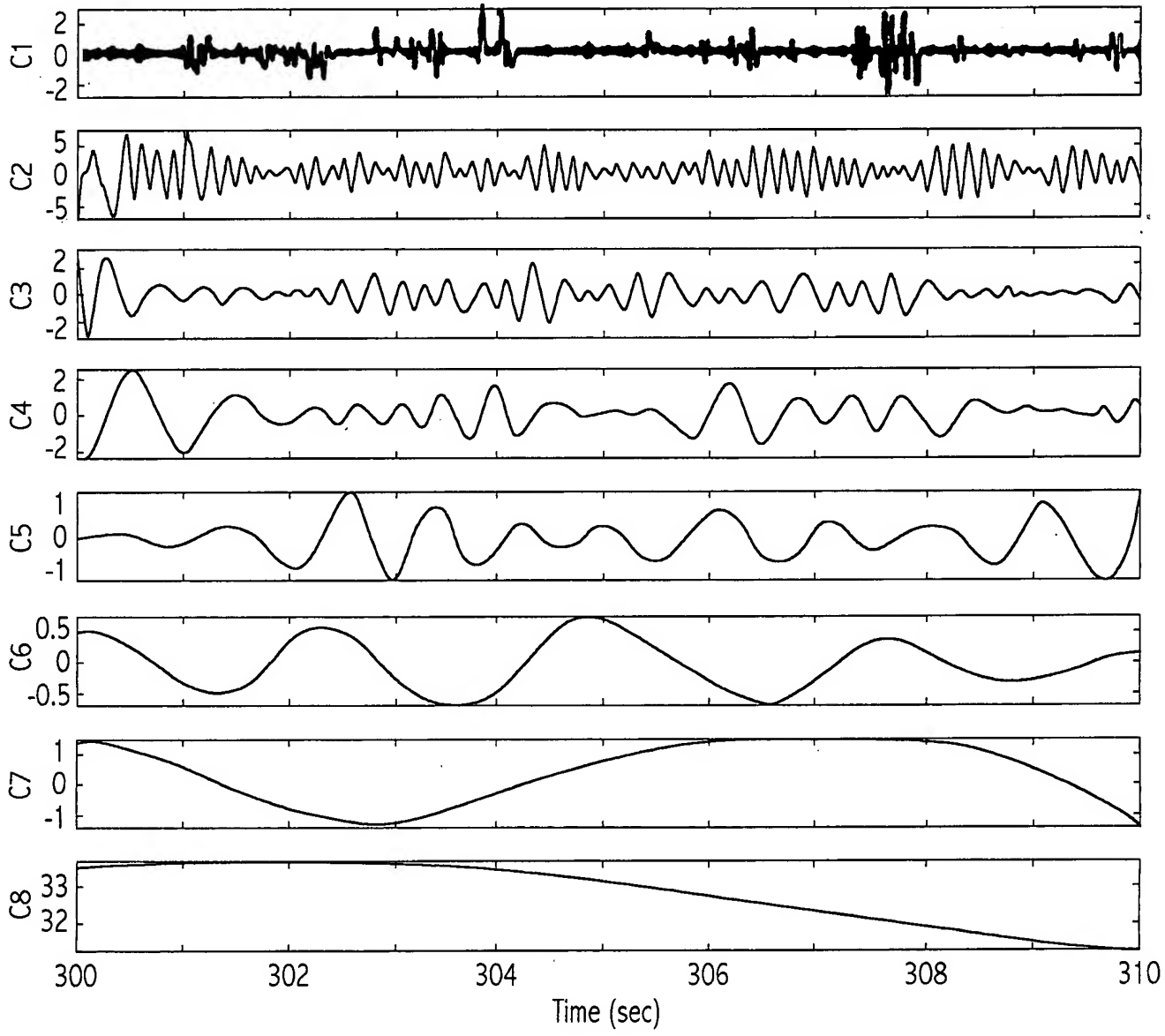
FIG. 11(d)

FIG. 11(e)

FIG. 11(f)

FIG. 11(g)

FIG. 11(h)



3DEP3D" Z596Z00P

FIG. 12(a)

FIG. 12(b)

FIG. 12(c)

FIG. 12(d)

FIG. 12(e)

FIG. 12(f)

FIG. 12(g)

FIG. 12(h)

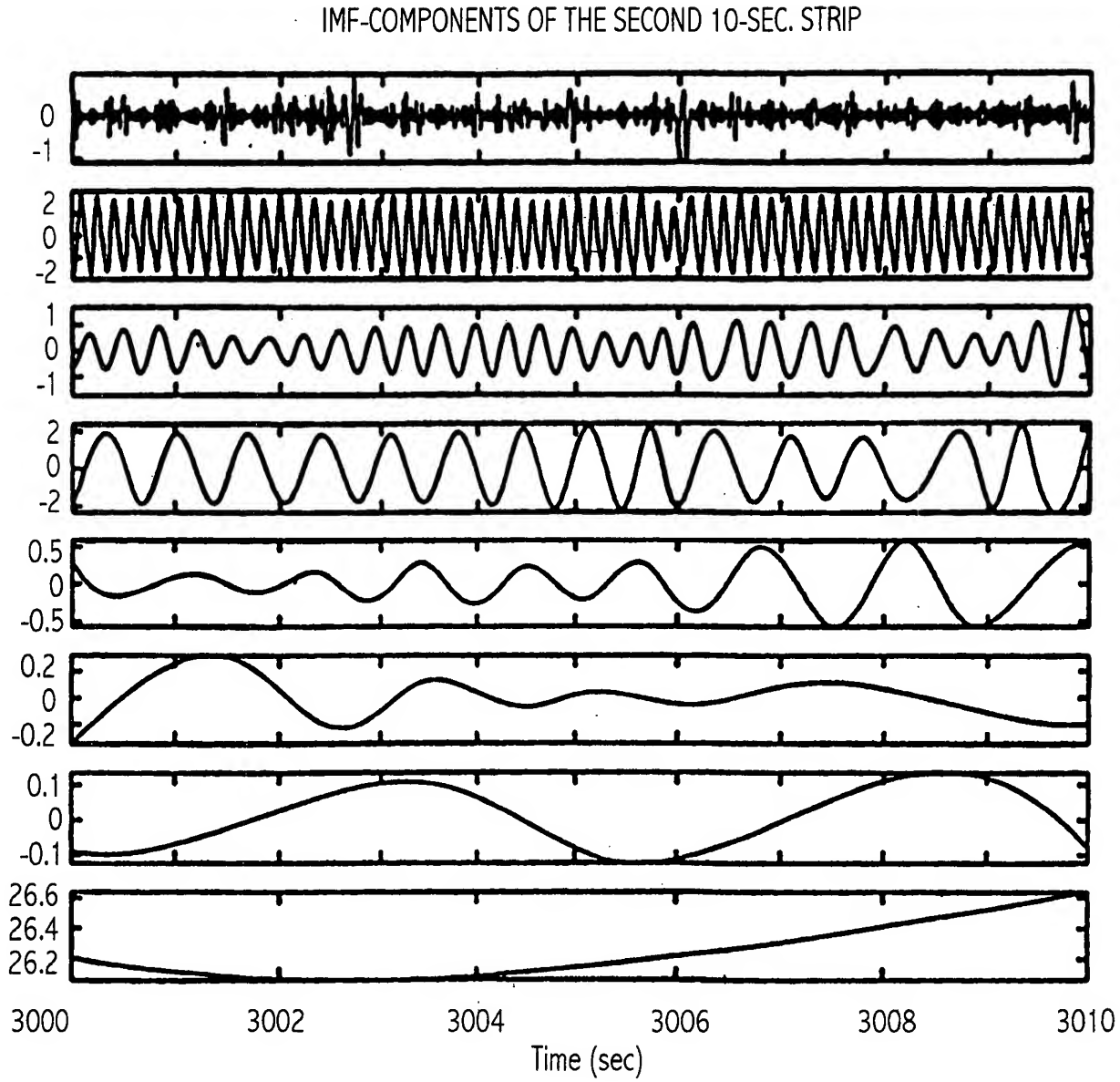


FIG. 13(a)

FIG. 13(b)

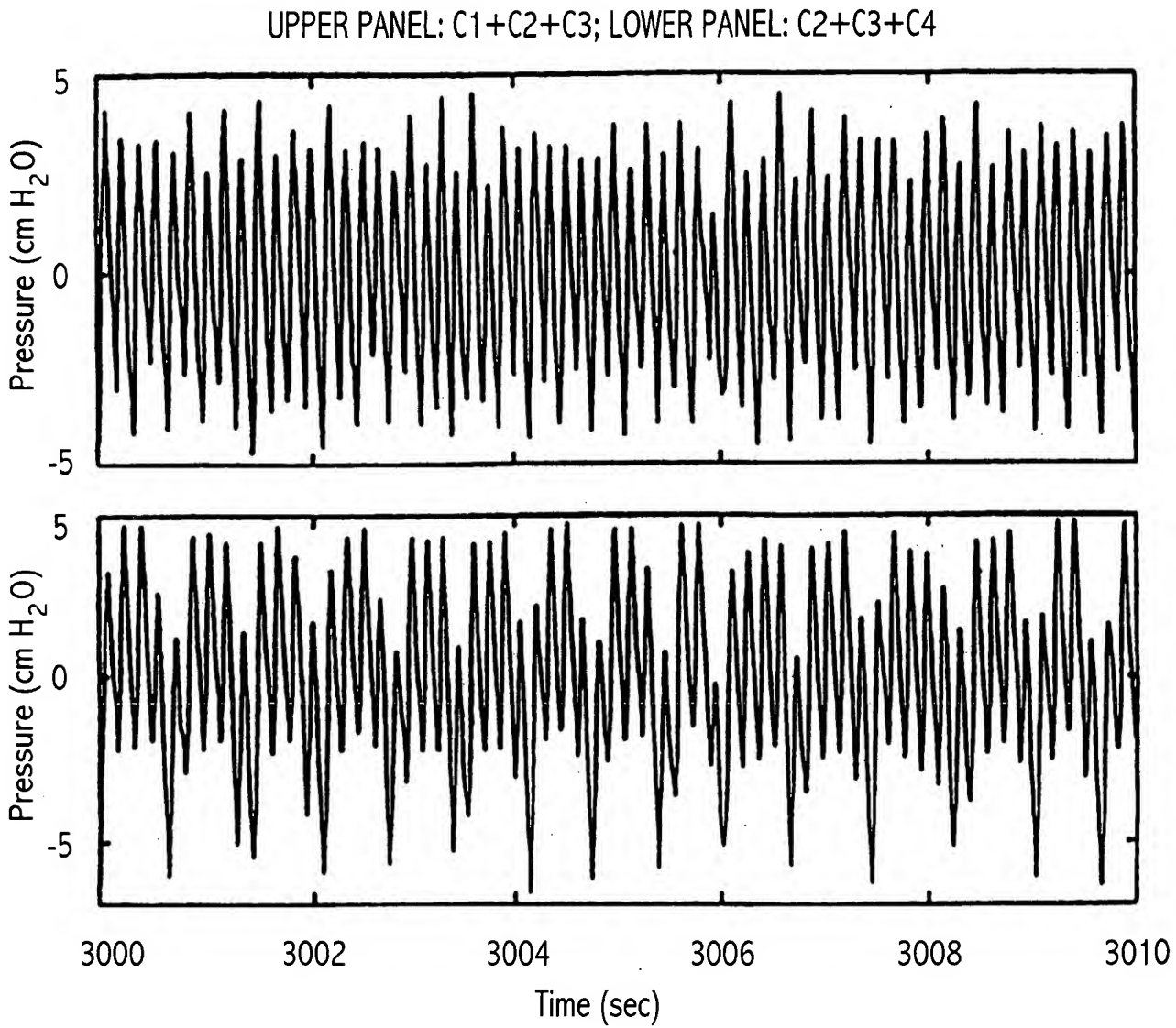


FIG. 13(c)

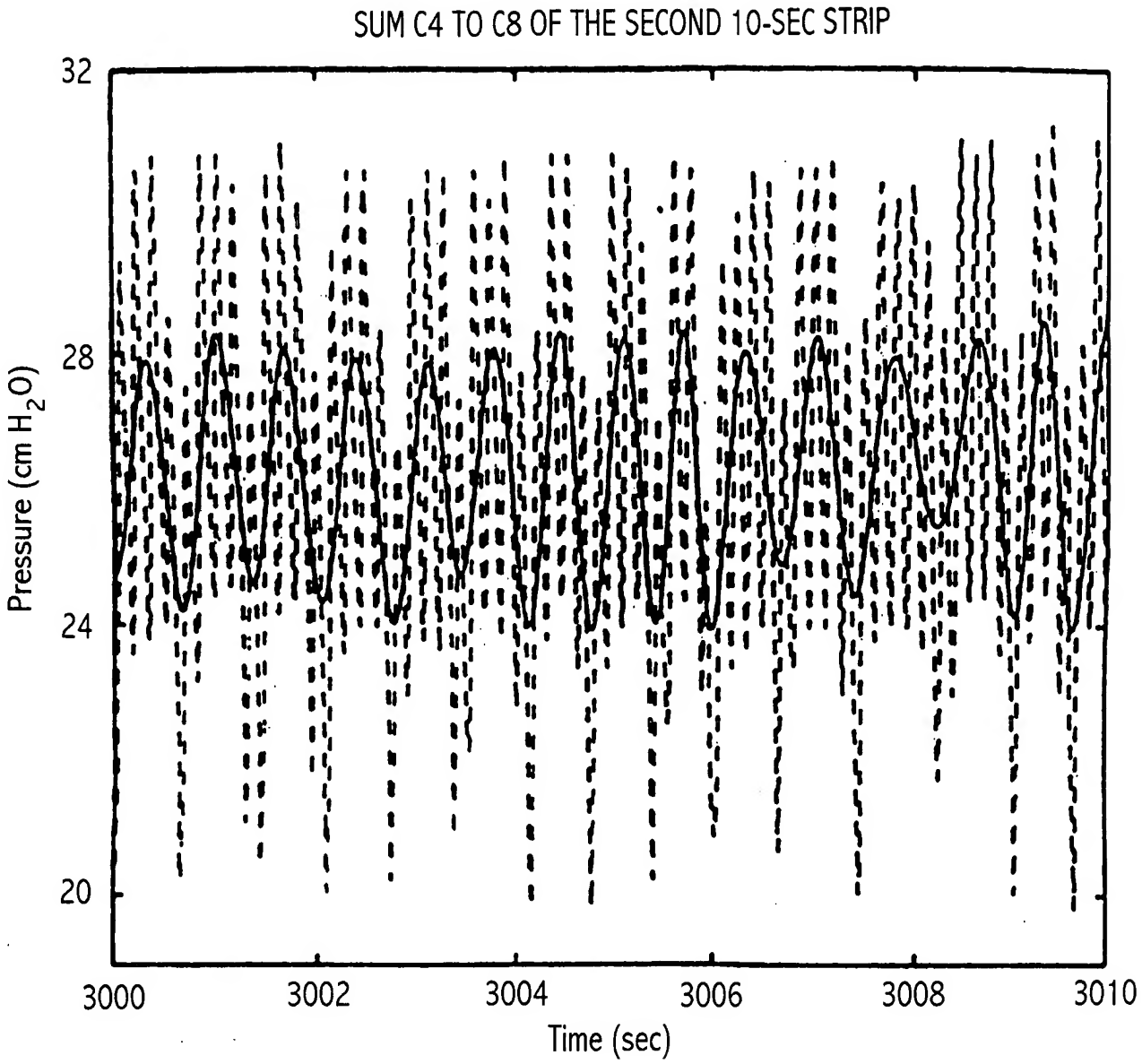

SUM C4 TO C8 OF THE SECOND 10-SEC STRIP
32
28
24
20
Pressure (cm H_2O)
3000
3002
3004
3006
3008
3010
Time (sec)

FIG. 15(h)

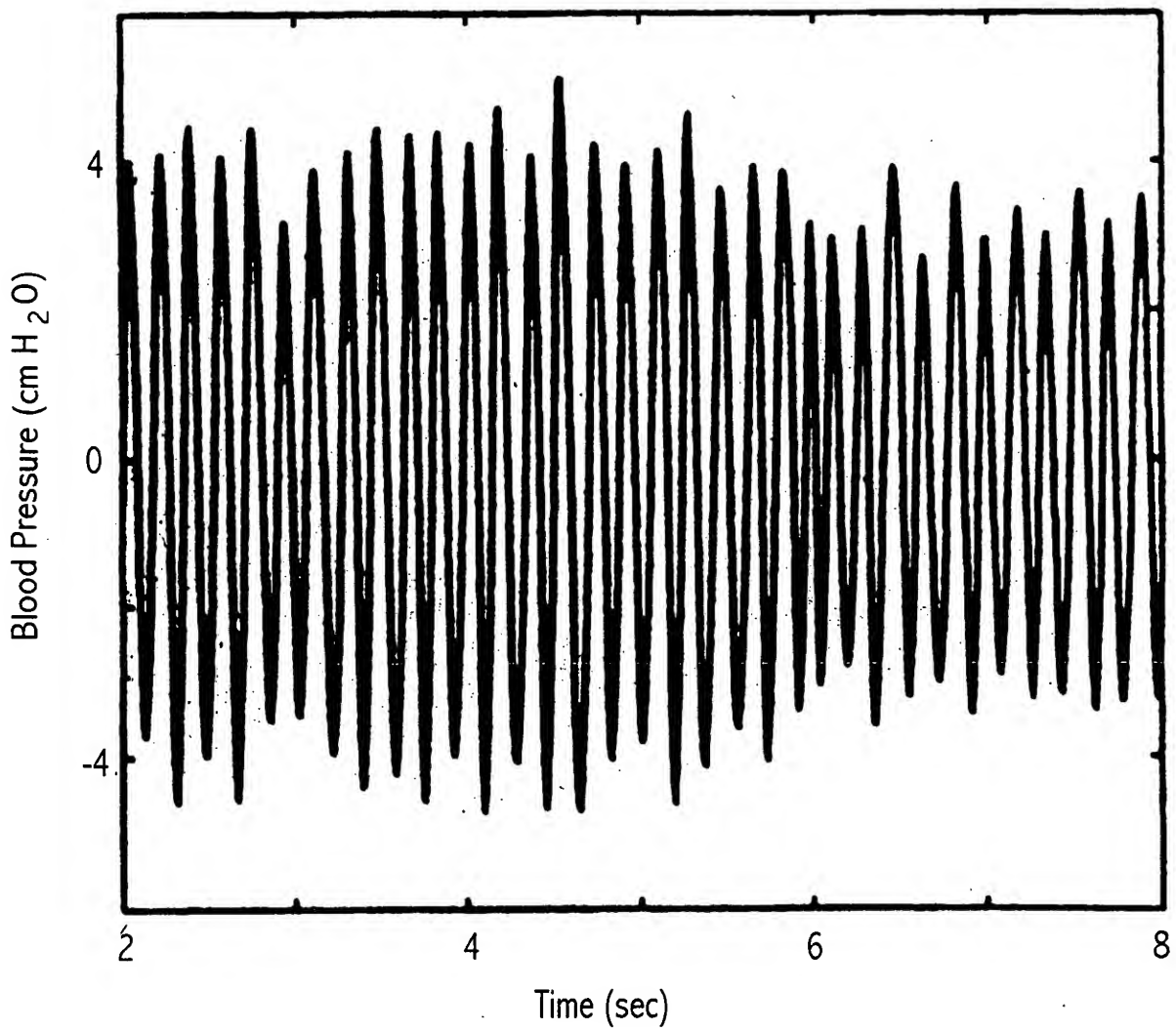


FIG. 16(g)

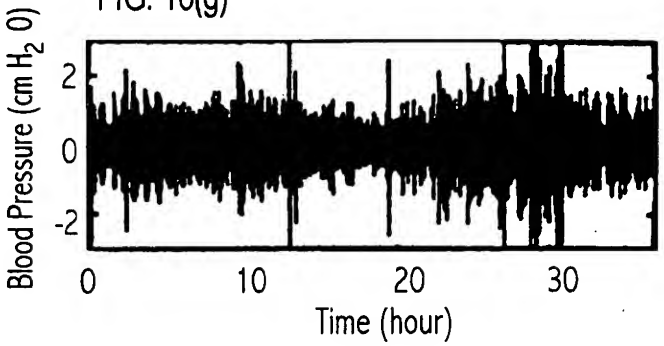


FIG. 16(h)

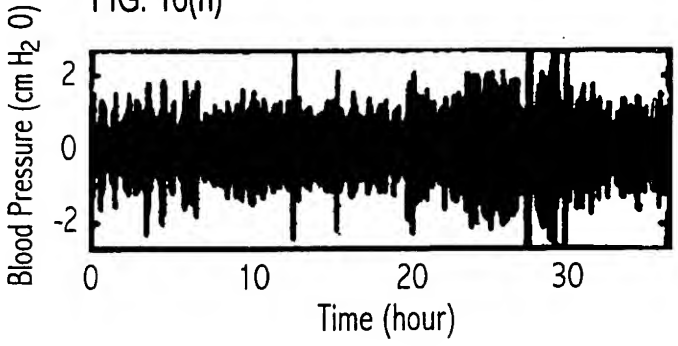


FIG. 16(i)

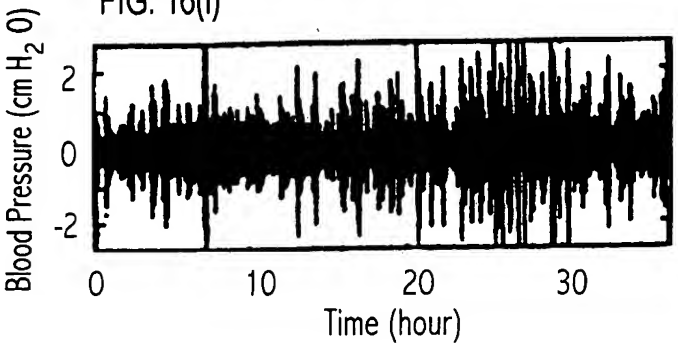


FIG. 16(j)

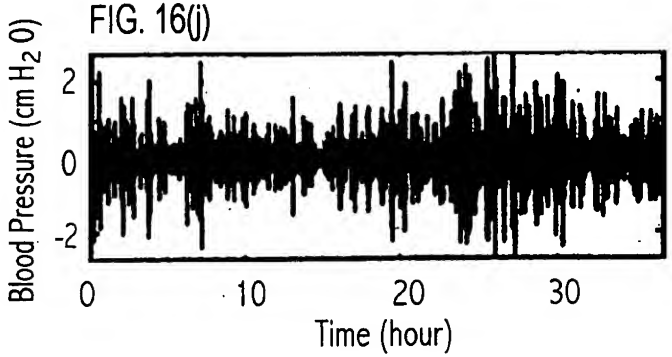


FIG. 16(k)

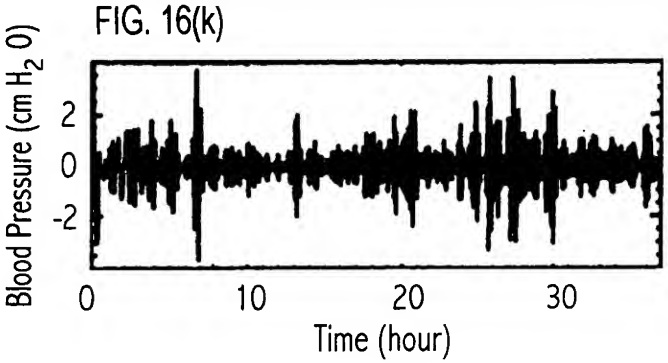


FIG. 16(l)

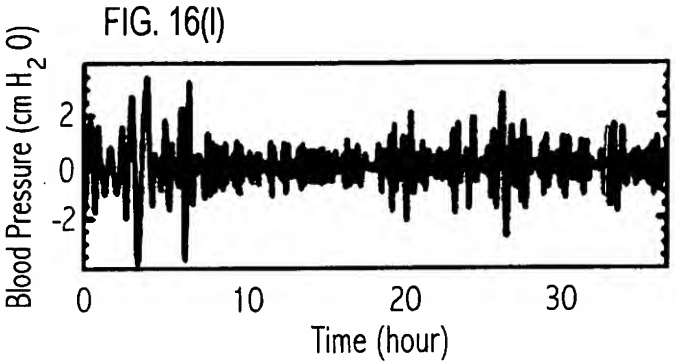


FIG. 18(a)

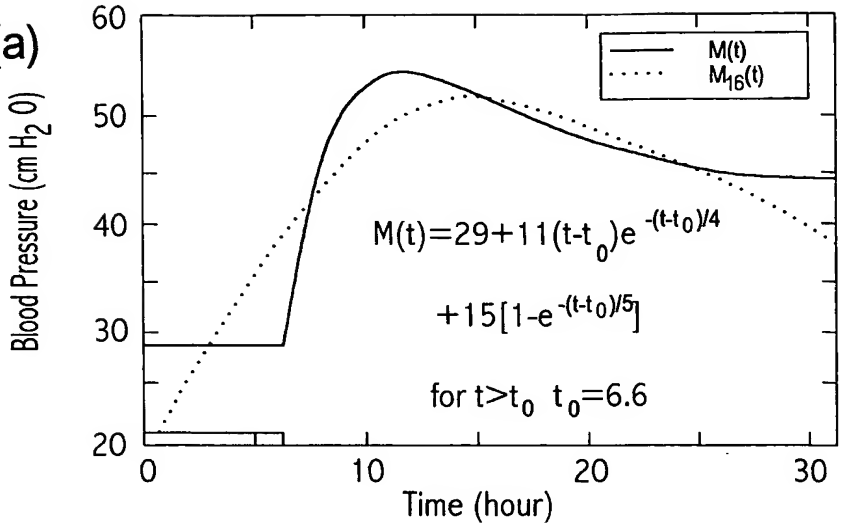


FIG. 18(b)

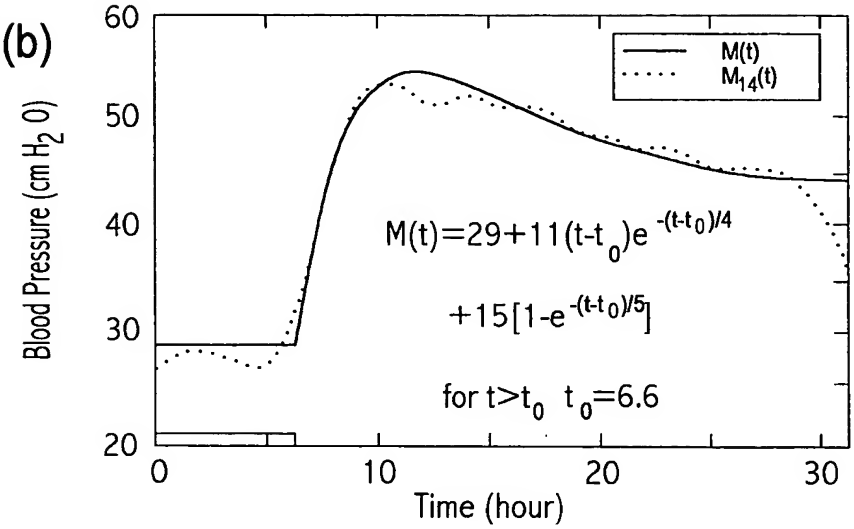


FIG. 18(c)

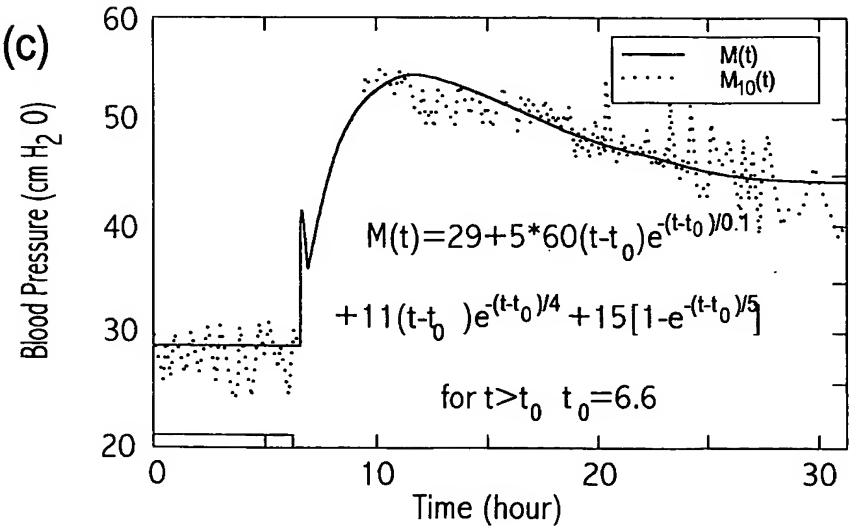


FIG. 19(a)

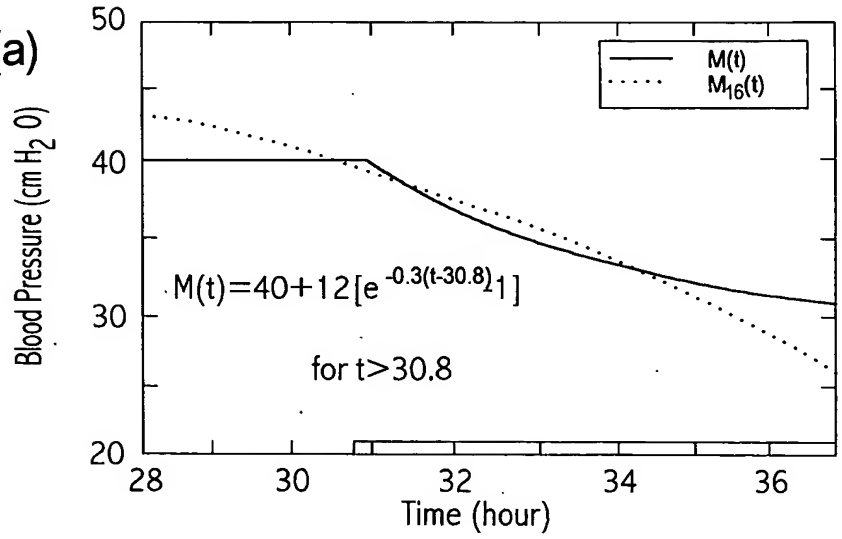


FIG. 19(b)

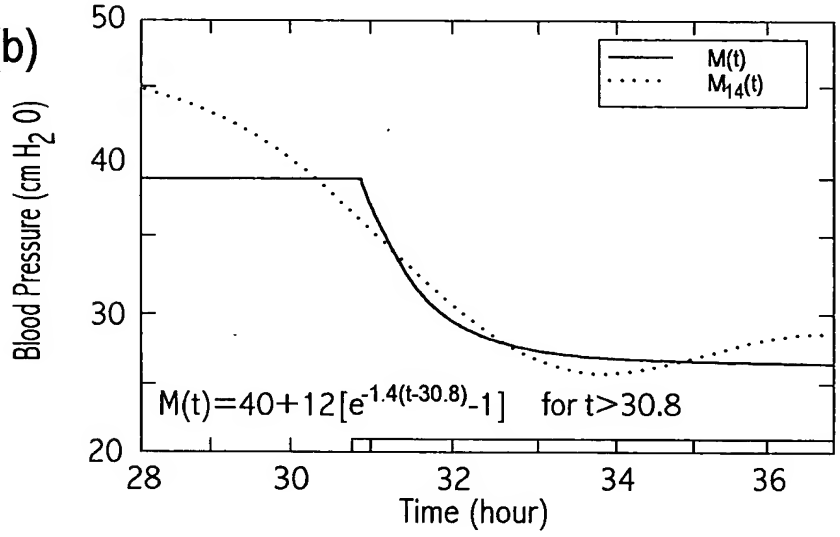


FIG. 19(c)

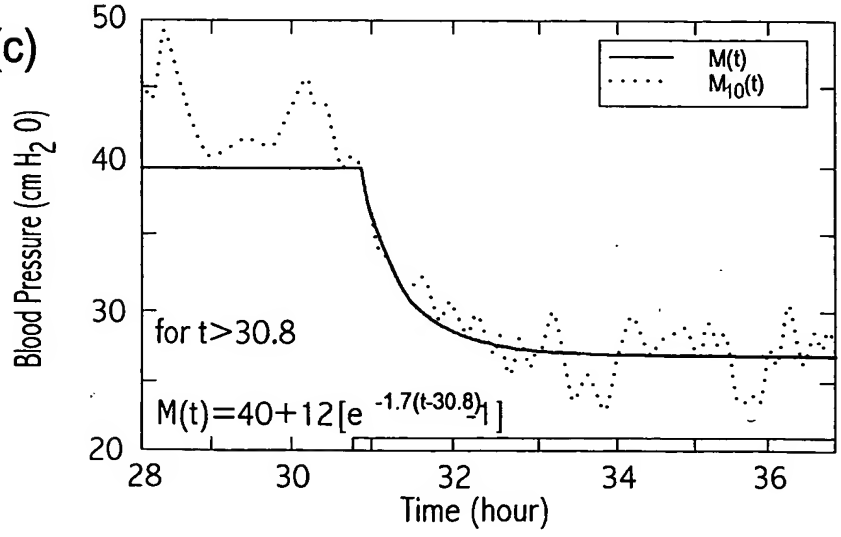


FIG. 16(m)

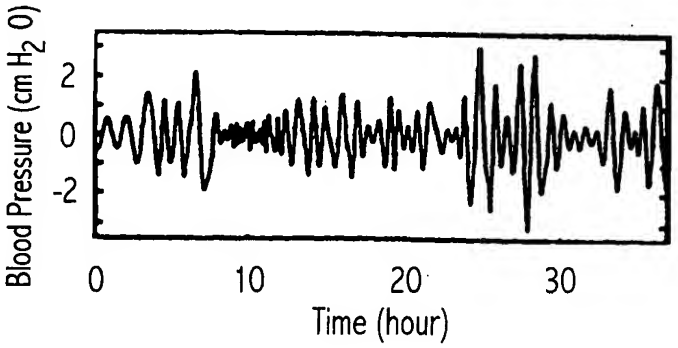


FIG. 16(n)

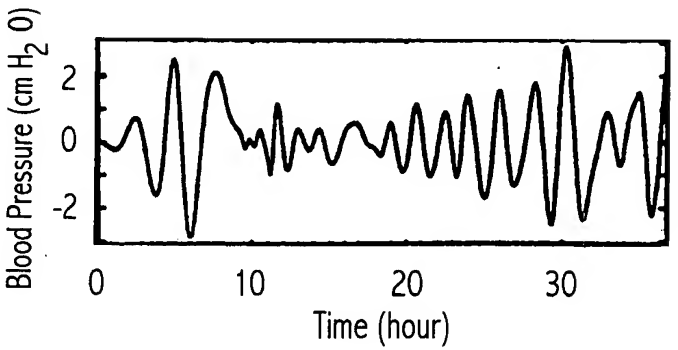


FIG. 16(o)

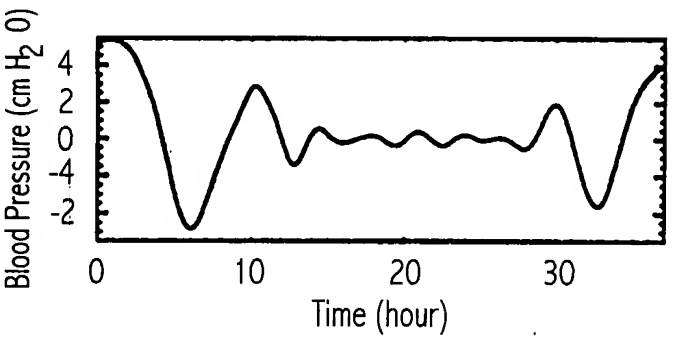


FIG. 16(p)

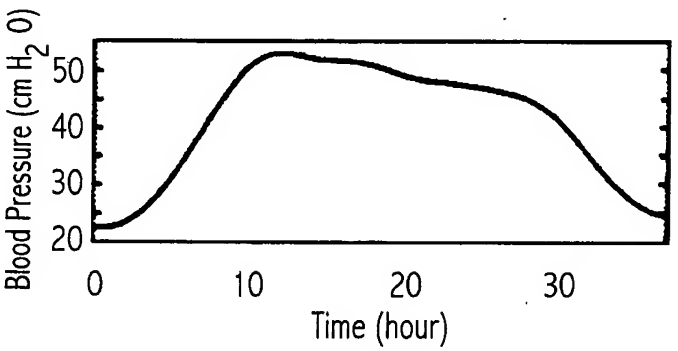


FIG. 15(g)

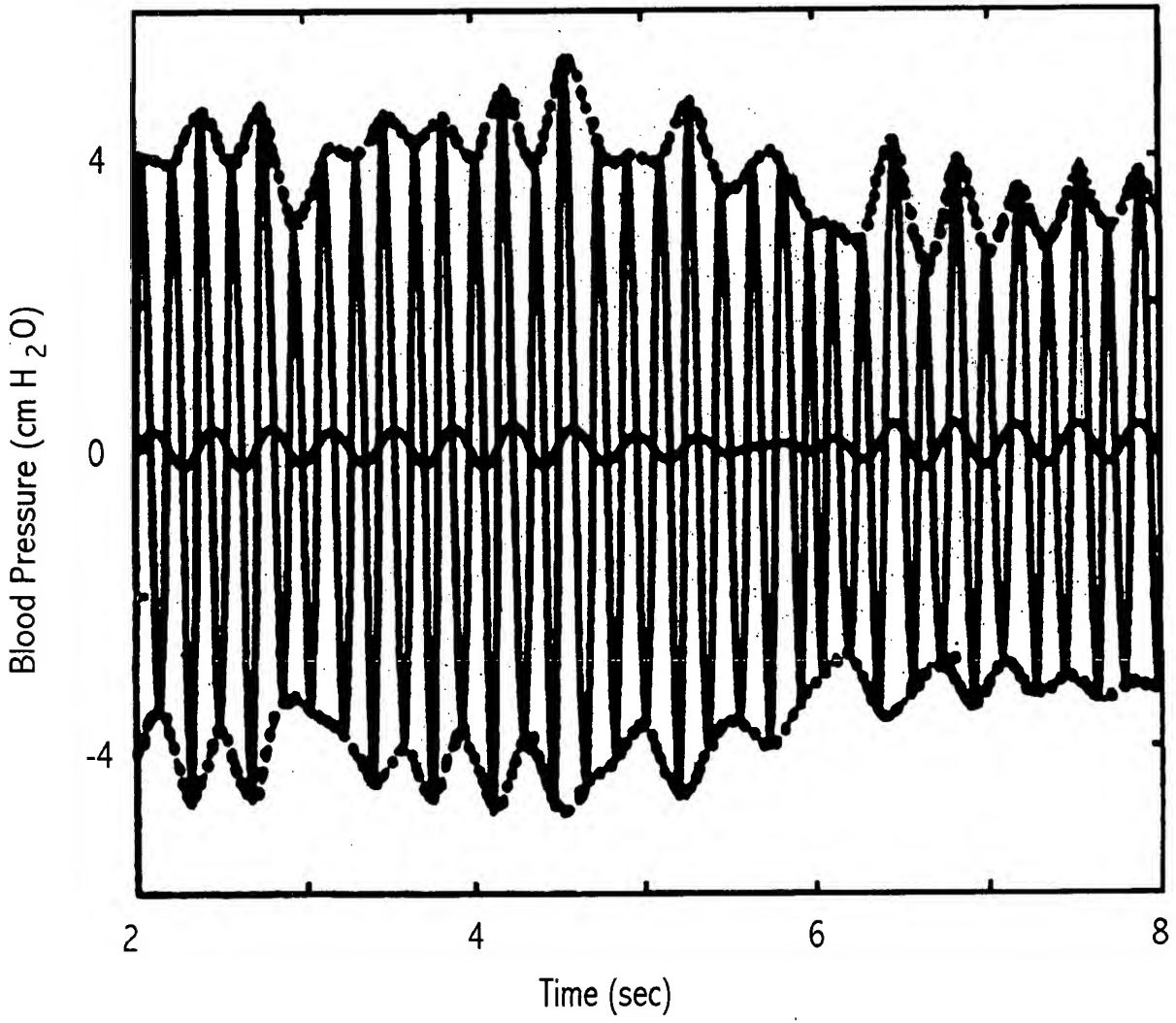


FIG. 14(a)

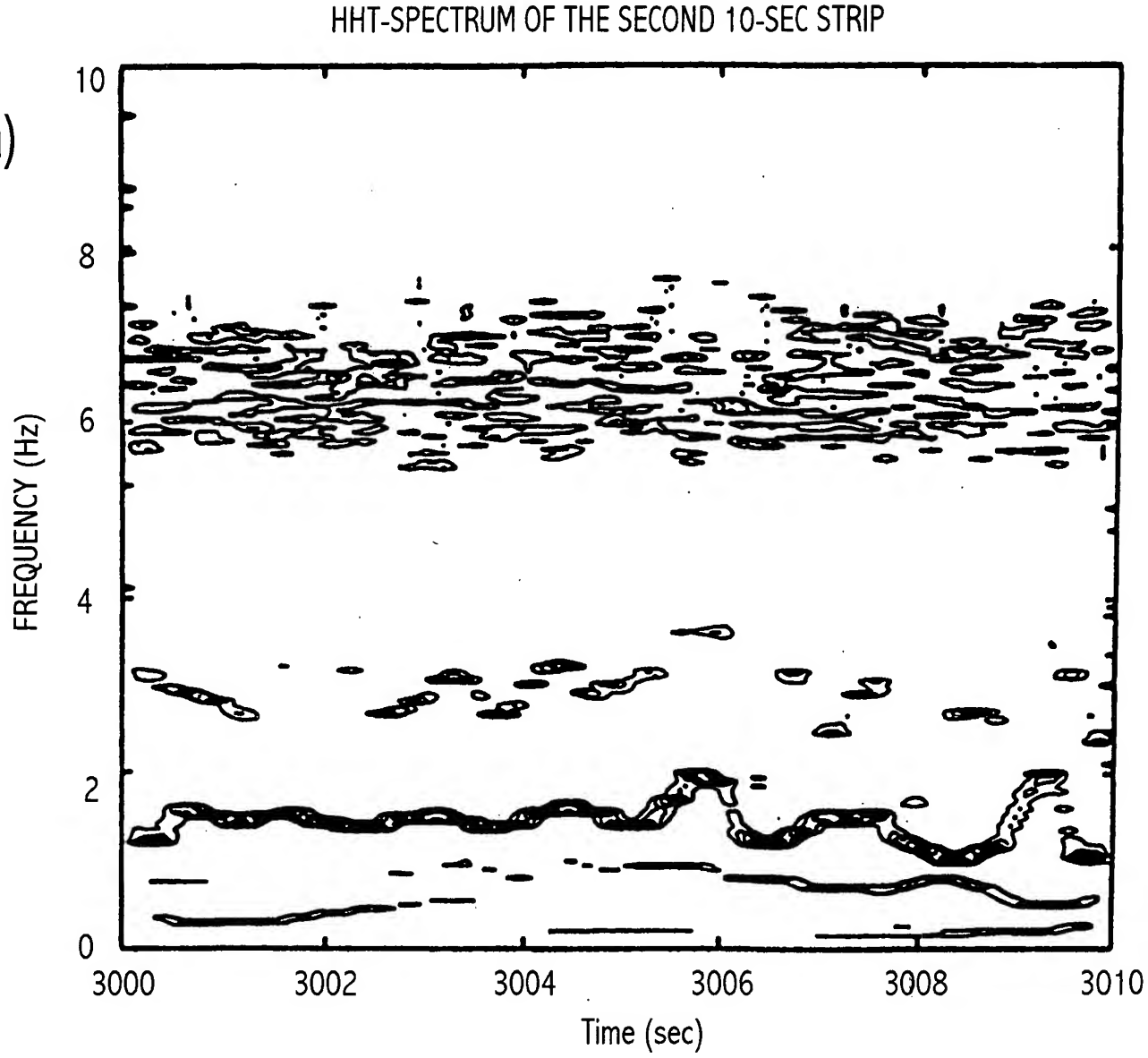

HHT-SPECTRUM OF THE SECOND 10-SEC STRIP
FREQUENCY (Hz)
10
8
6
4
2
0
3000
3002
3004
3006
3008
3010
Time (sec)

FIG. 14(b)

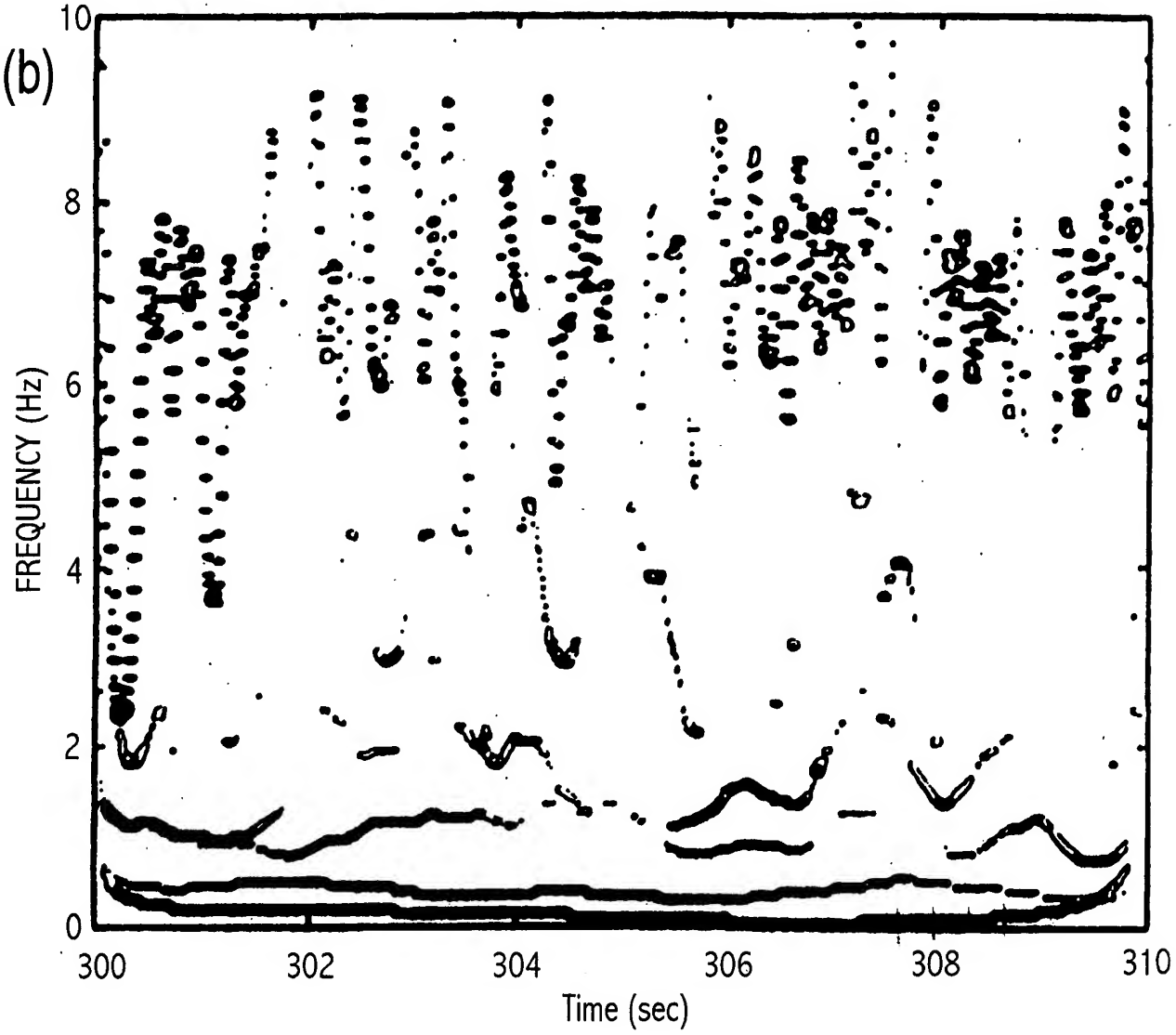

HHT-SPECTRUM OF THE FIRST 10-SEC STRIP
FREQUENCY (Hz)
0
2
4
6
8
10
300
302
304
306
308
310
Time (sec)

FIG. 15(a)

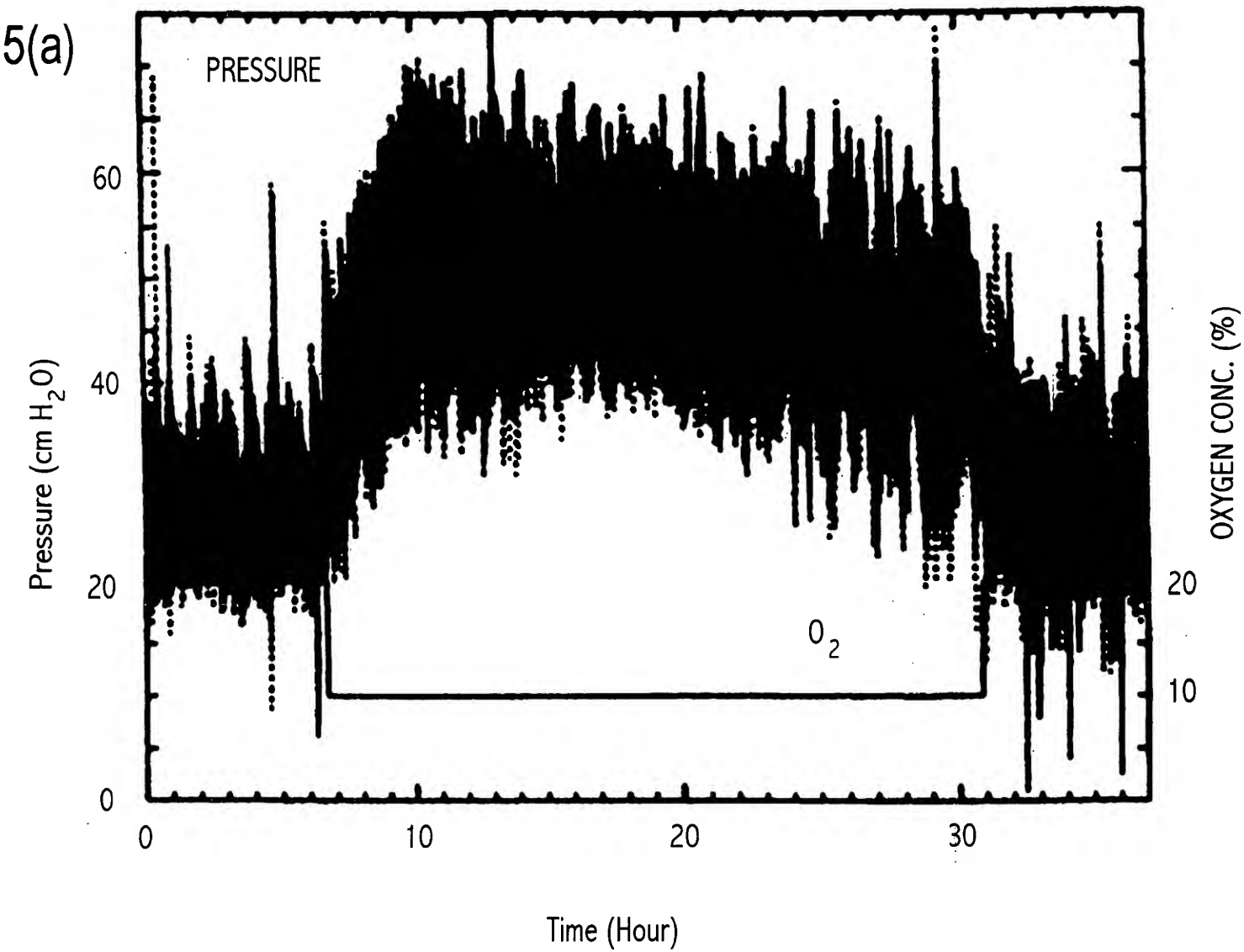

PRESSURE
60
40
20
0
Pressure (cm H_2O)
O_2
20
10
OXYGEN CONC. (%)
0
10
20
30
Time (Hour)

FIG. 15(b)

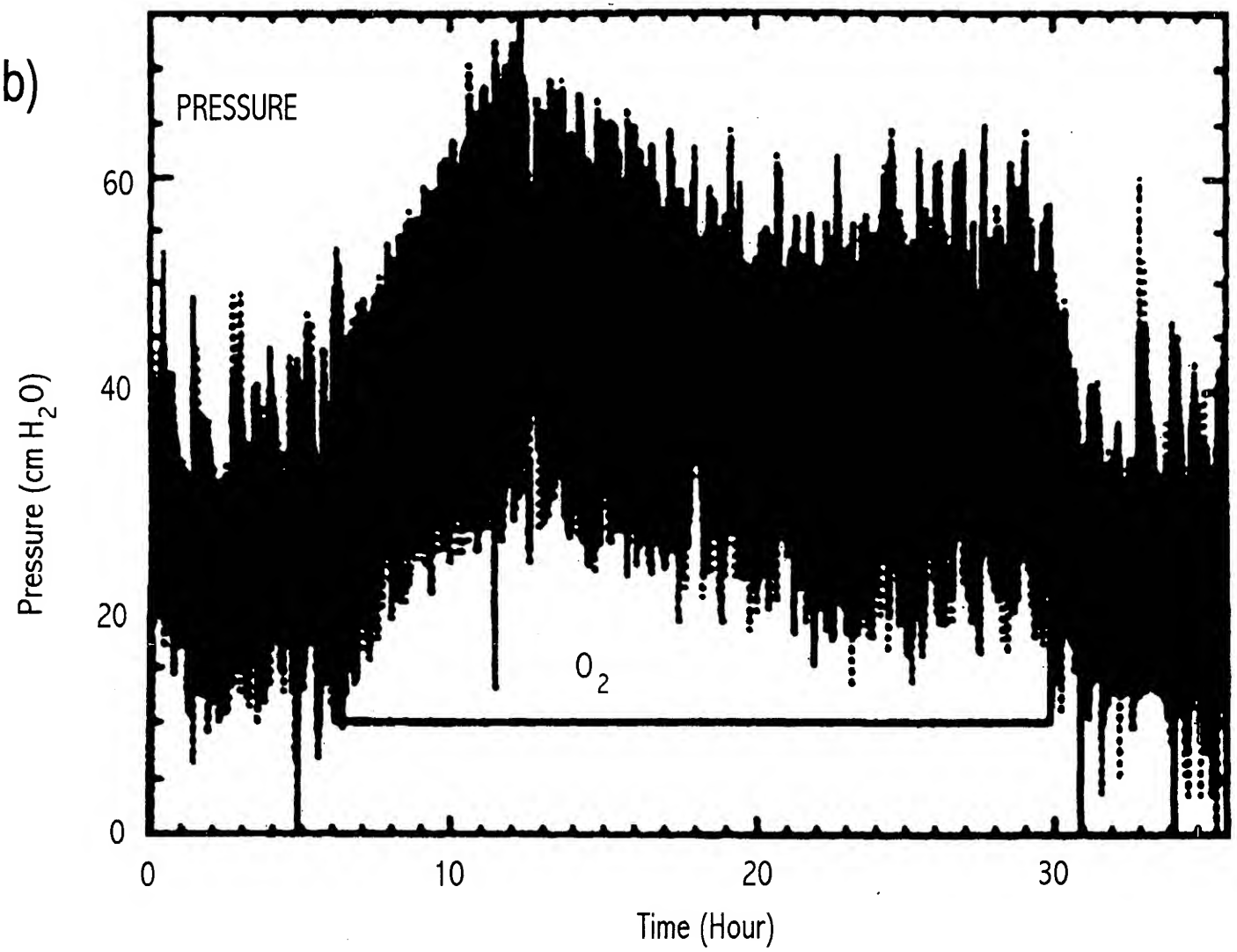


FIG. 15(c)

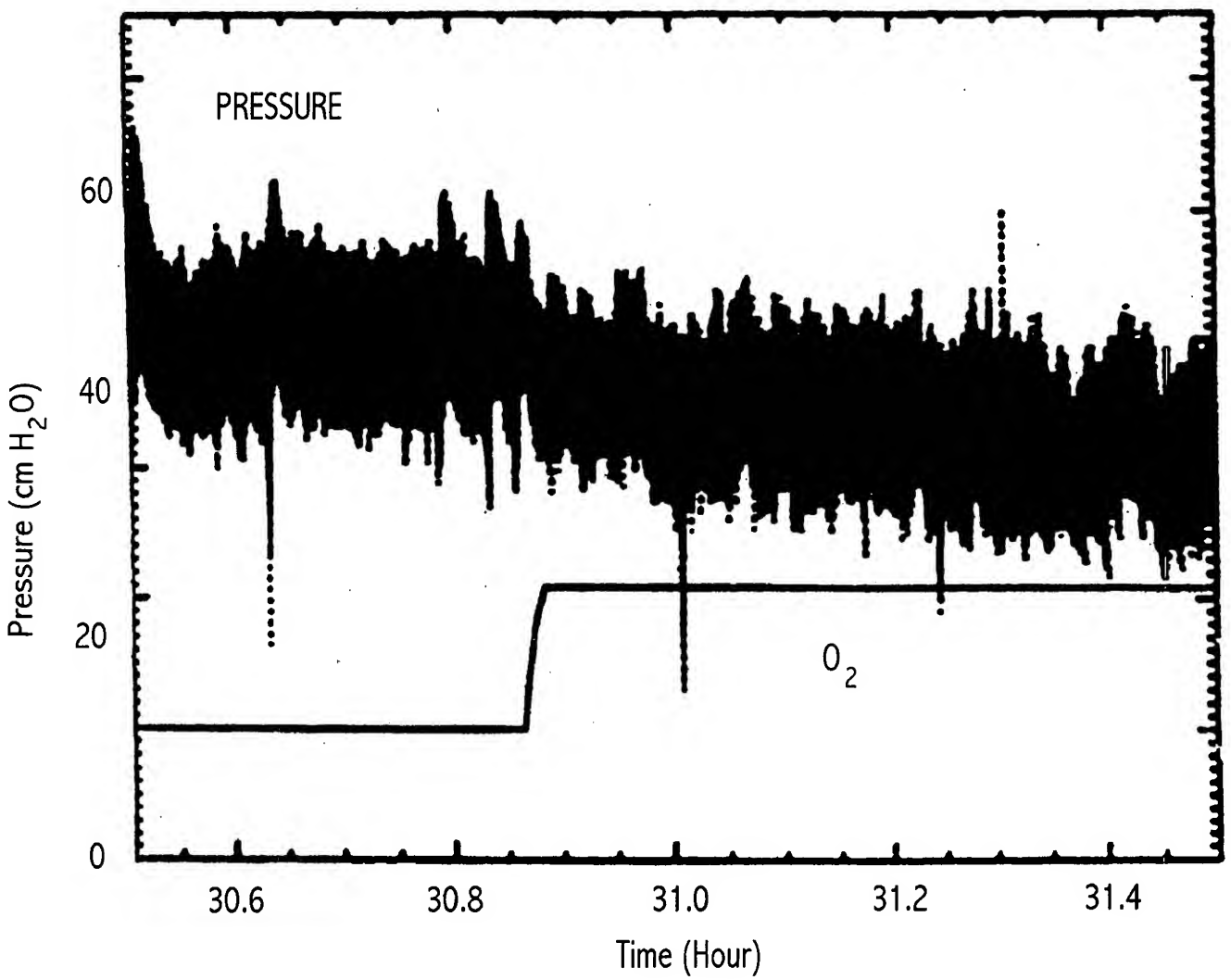

PRESSURE
60
40
20
0
Pressure (cm H_2O)
O_2
30.6
30.8
31.0
31.2
31.4
Time (Hour)

FIG. 15(d)

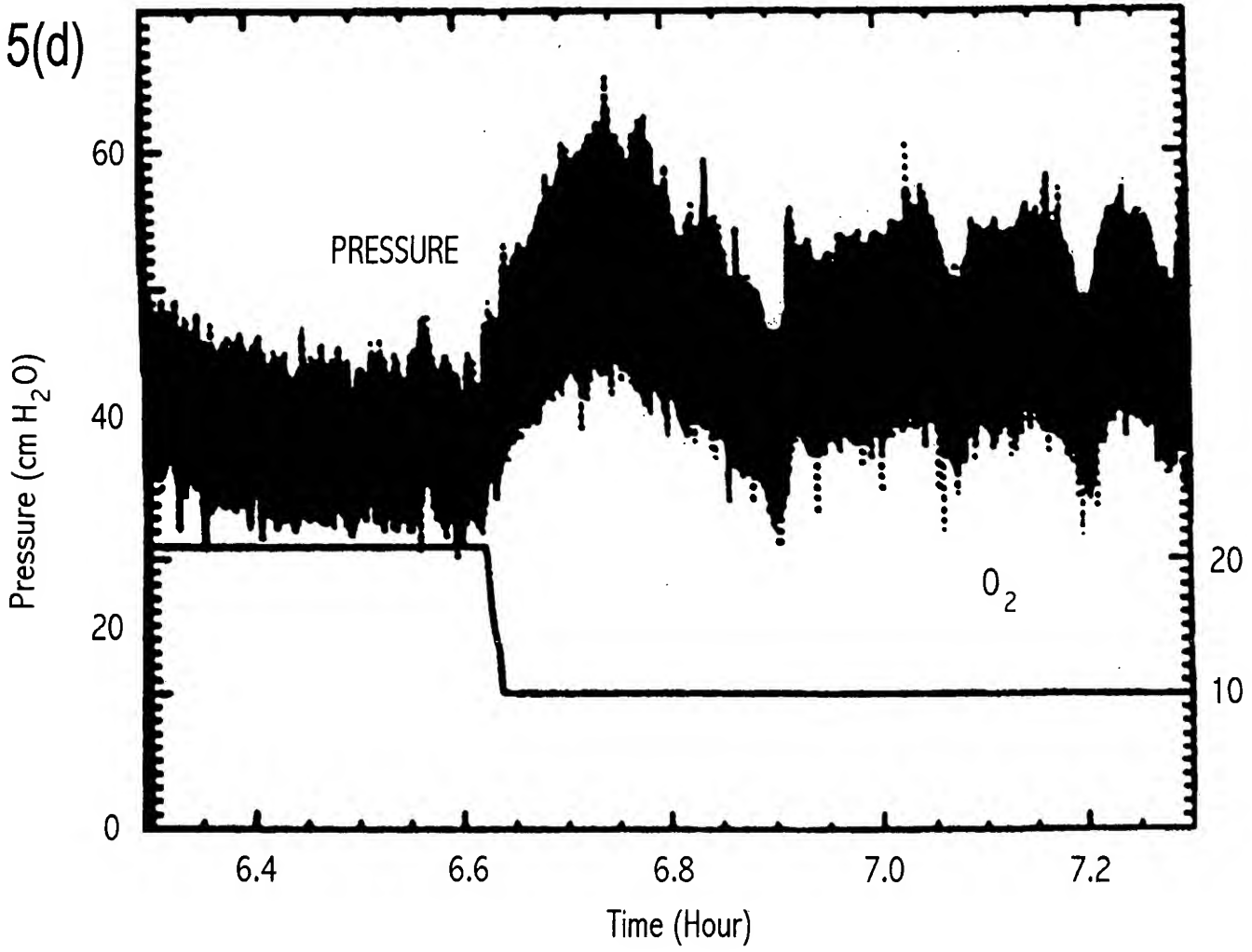

PRESSURE
O_2
Pressure (cm H_2O)
60
40
20
0
20
10
6.4
6.6
6.8
7.0
7.2
Time (Hour)

FIG. 15(e)

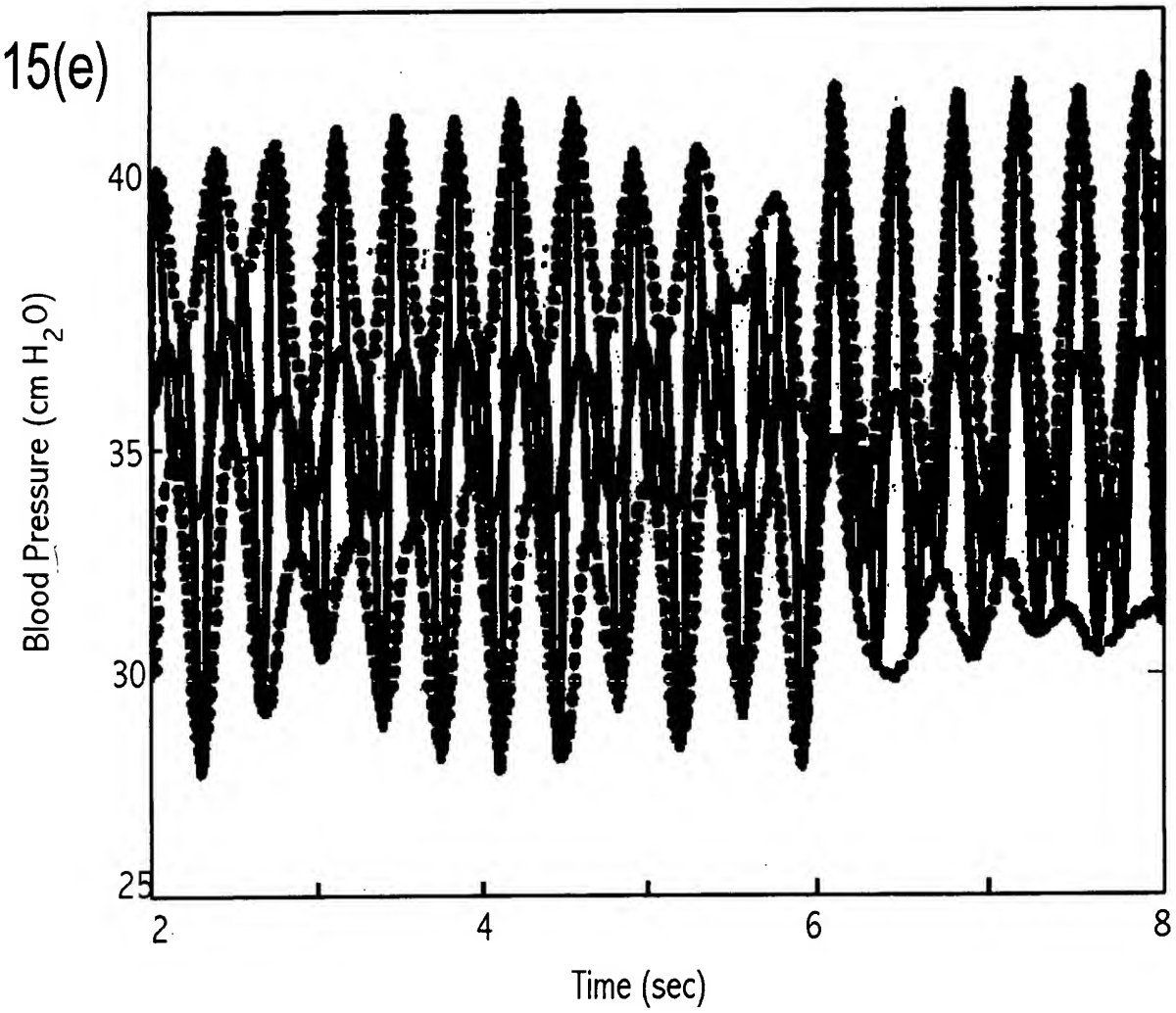


FIG. 15(f)

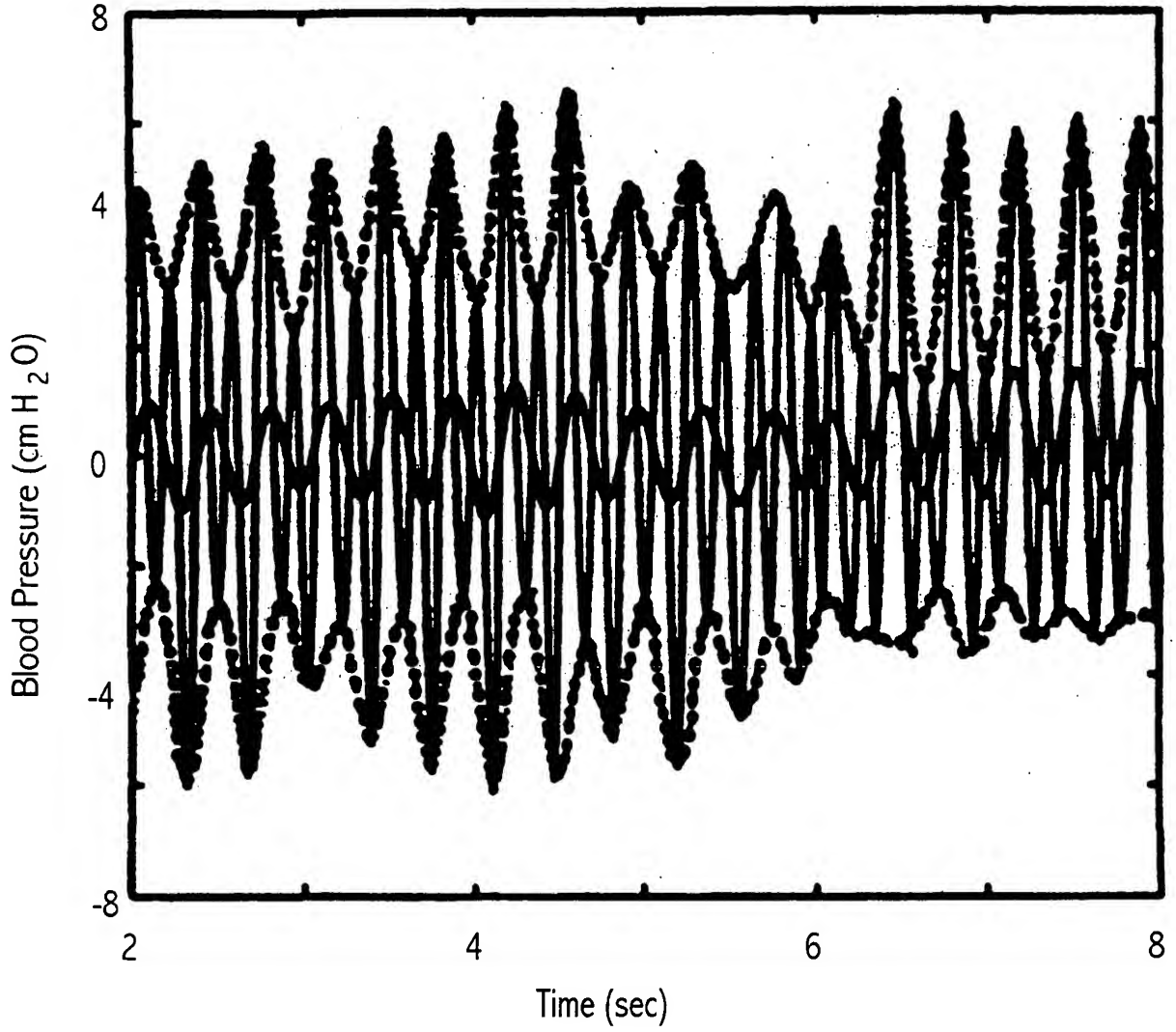


FIG. 16(a)

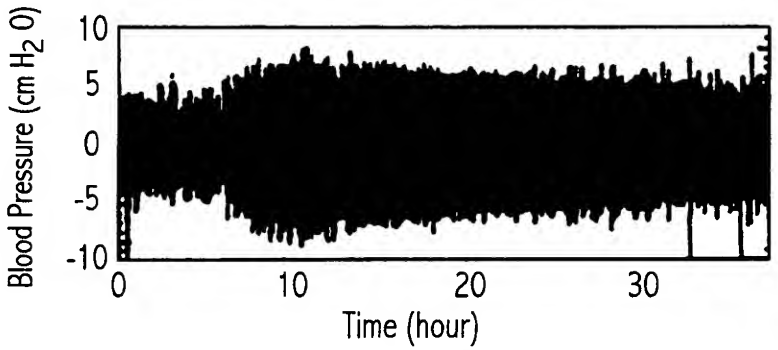


FIG. 16(b)

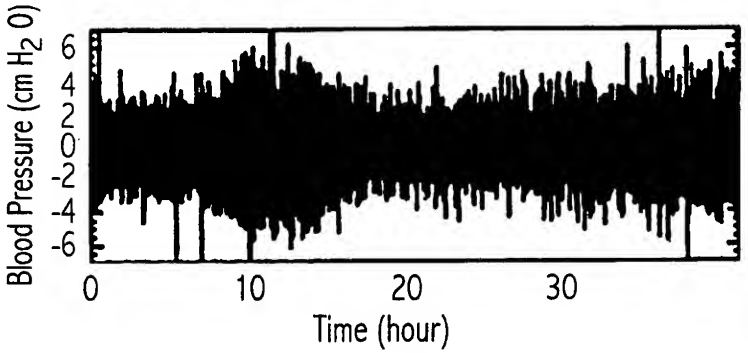


FIG. 16(c)

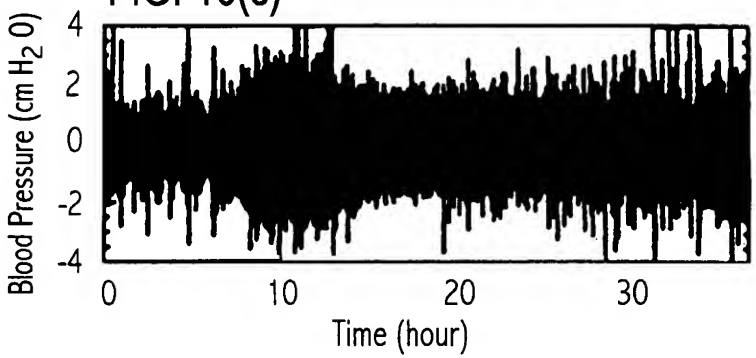


FIG. 16(d)

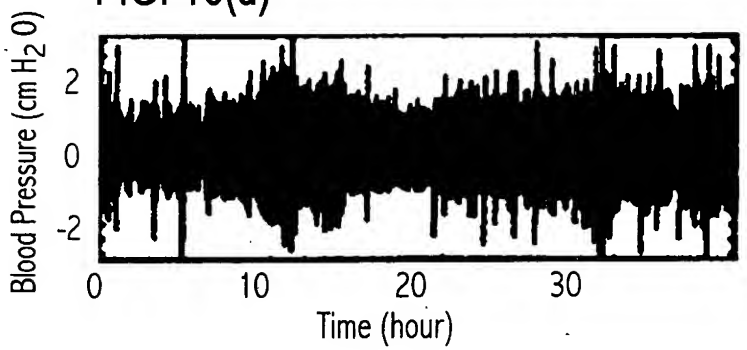


FIG. 16(e)

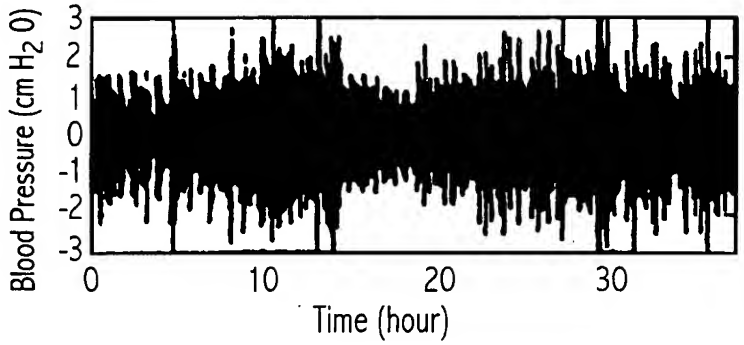


FIG. 16(f)

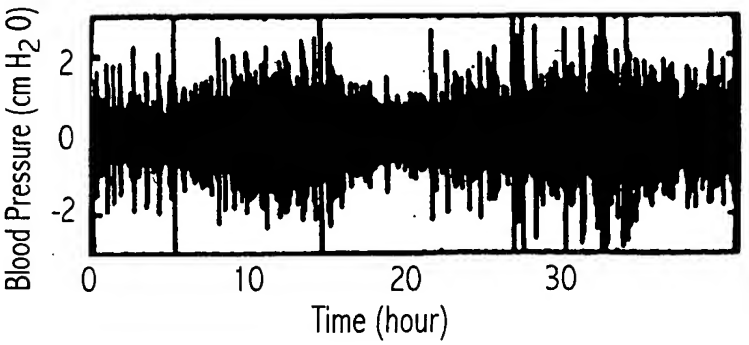


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FIG. 17(a)

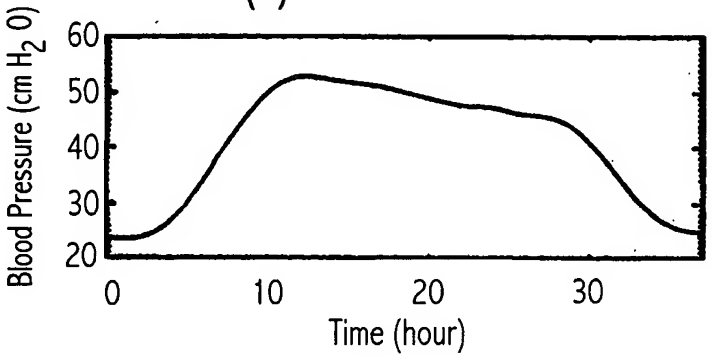


FIG. 17(b)

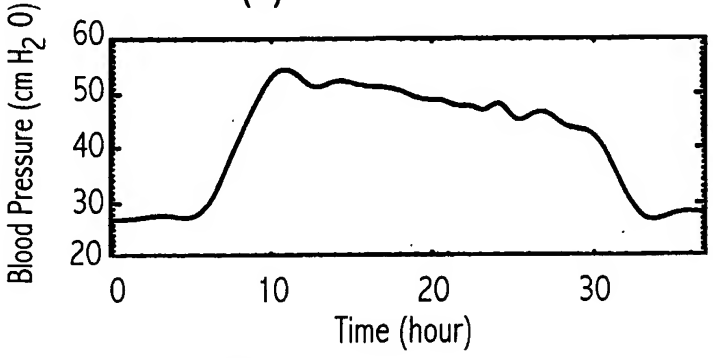


FIG. 17(c)

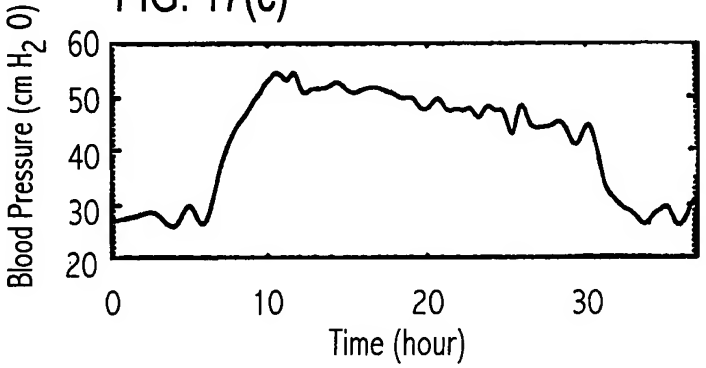


FIG. 17(d)

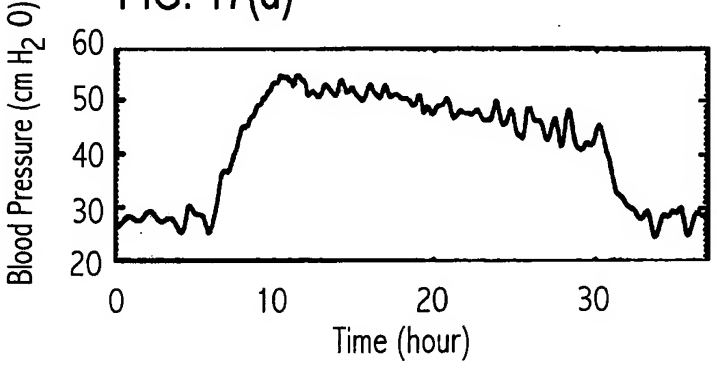


FIG. 17(e)

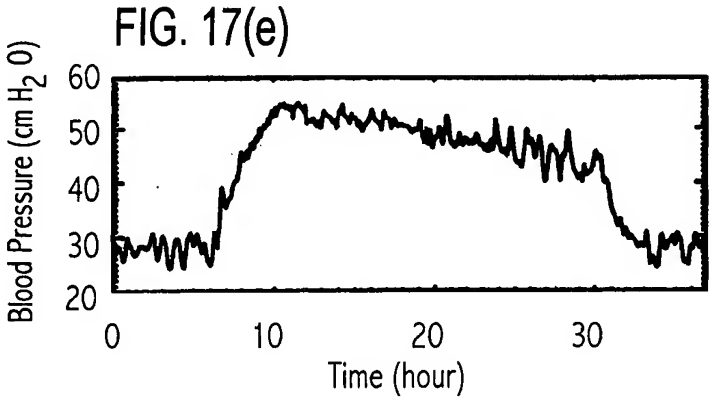


FIG. 17(f)

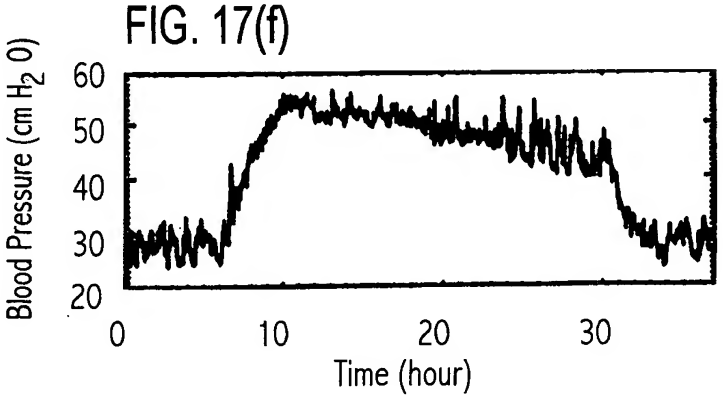


FIG. 20(a)

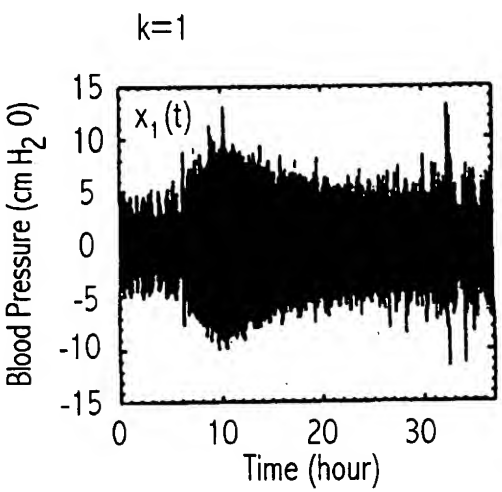


FIG. 20(b)

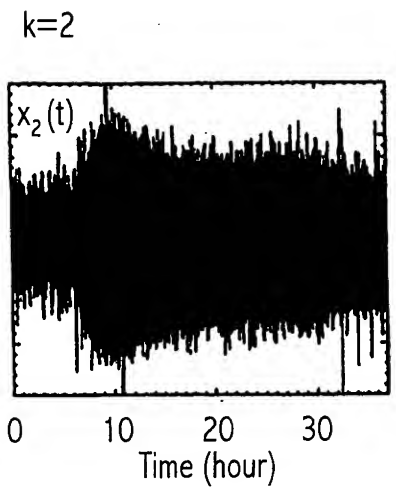


FIG. 20(c)

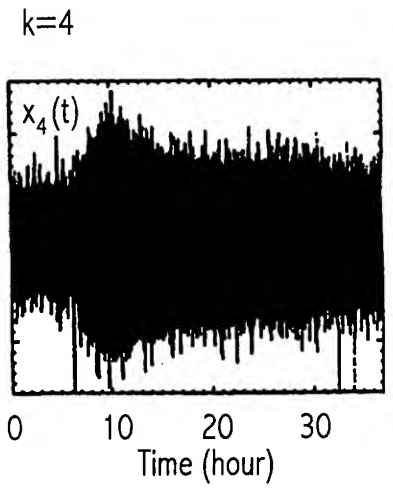


FIG. 20(d)

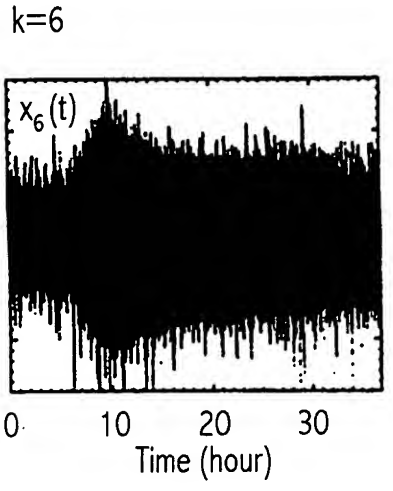
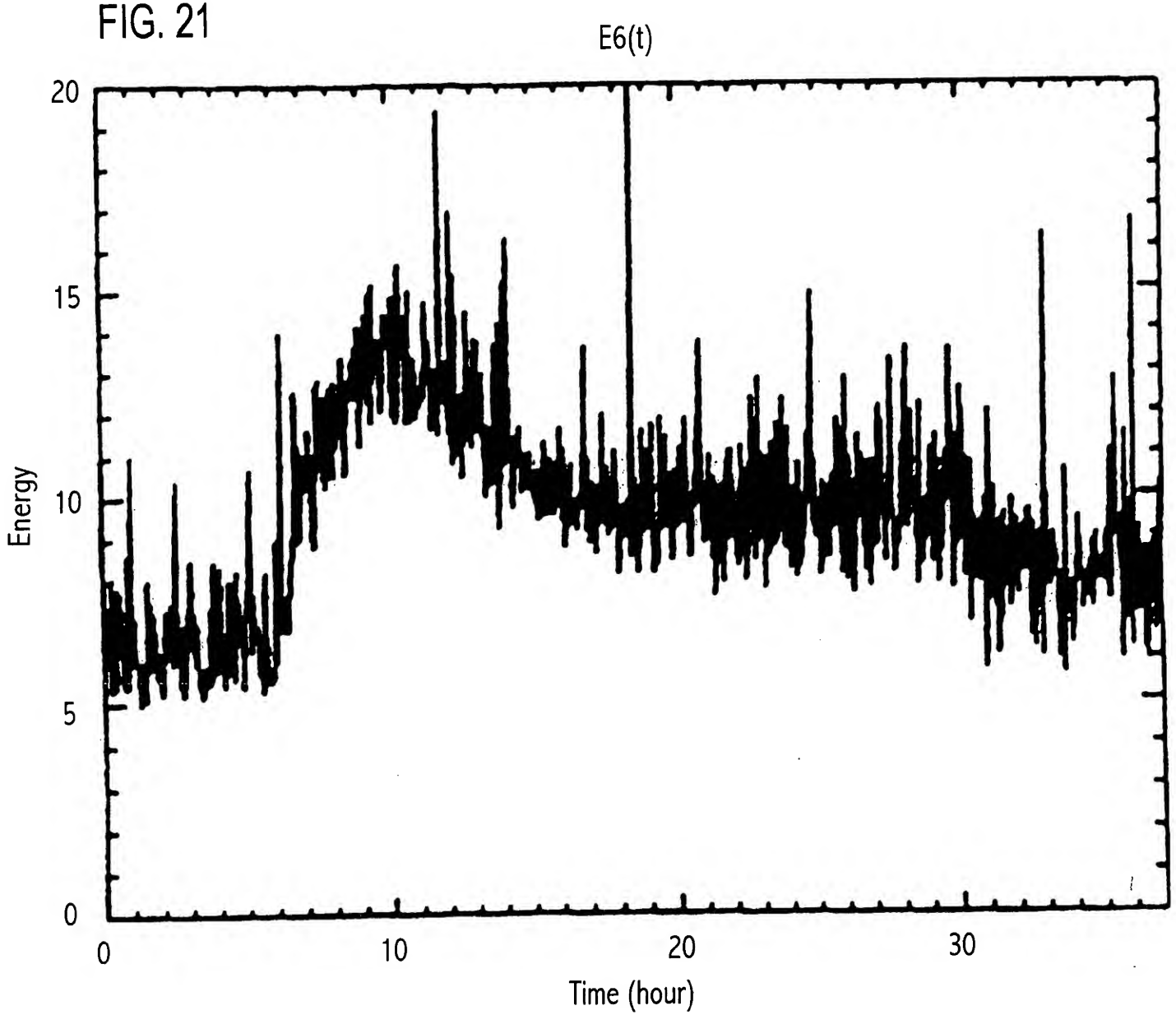


FIG. 21



3961201 2562001

CEK(t): k=9-12

FIG. 22(a)

FIG. 22(b)

FIG. 22(c)

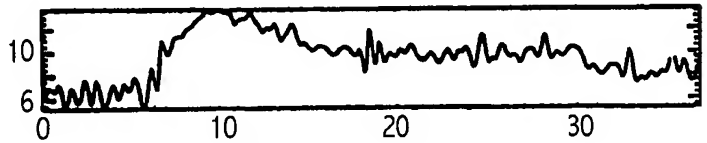
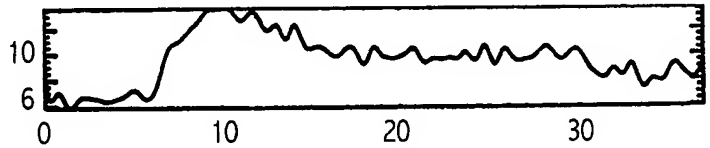


FIG. 22(d)



CEK(t): k=13-16

FIG. 22(e)

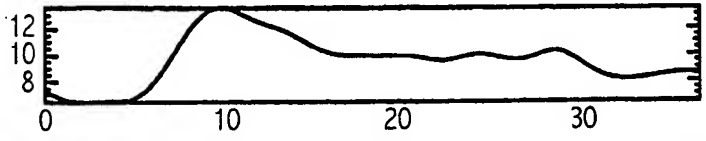


FIG. 22(f)

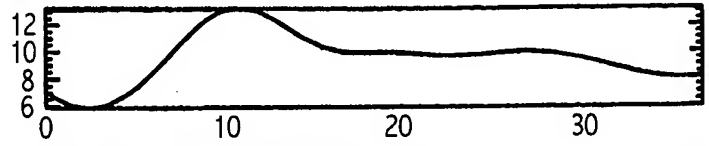


FIG. 22(g)

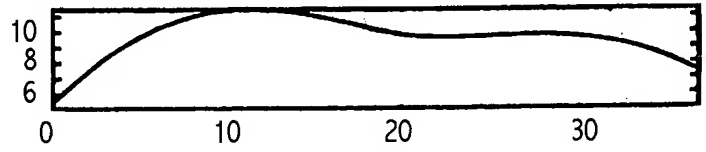


FIG. 22(h)

FIG. 23(a)

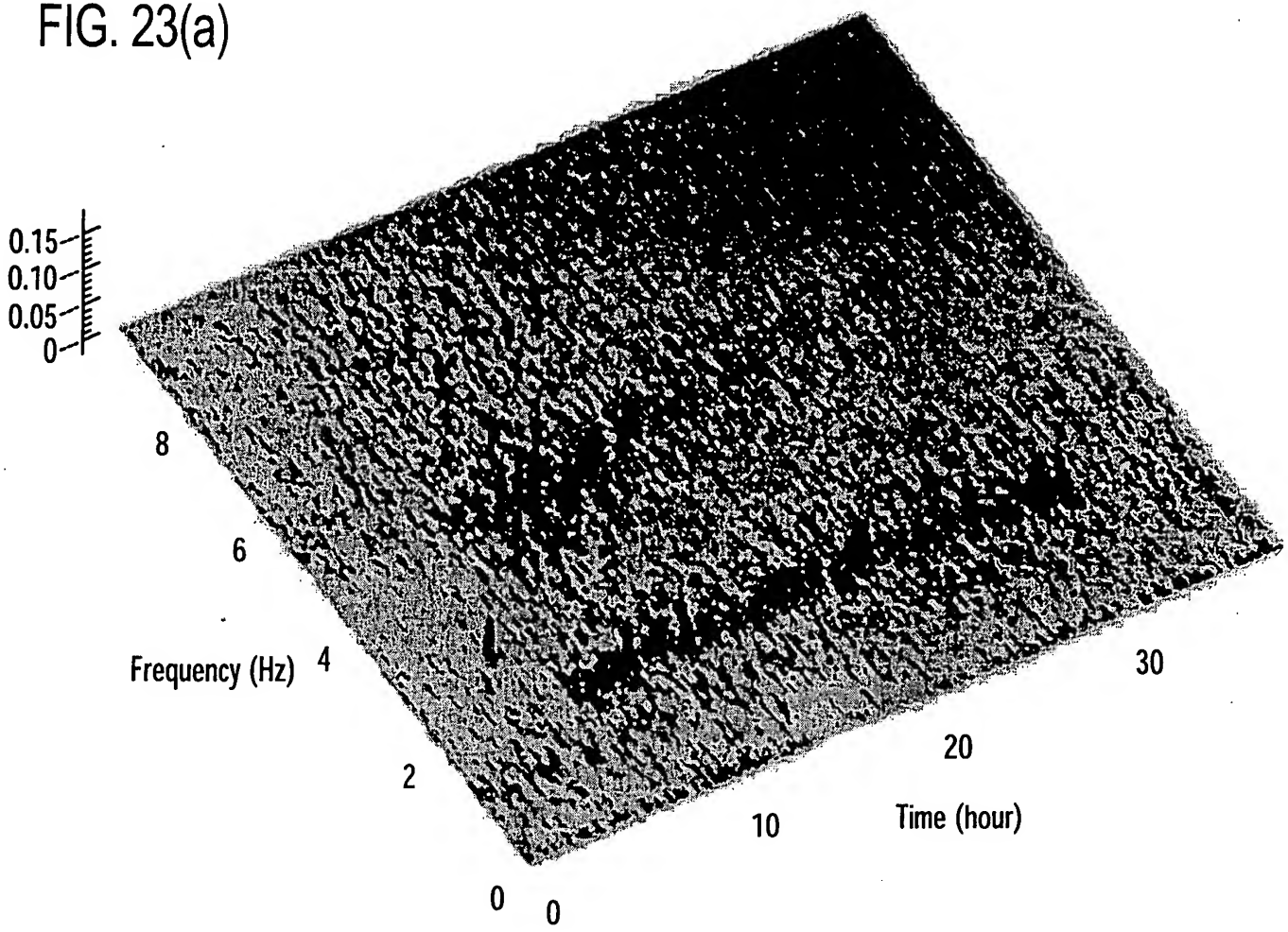


FIG. 23(b)

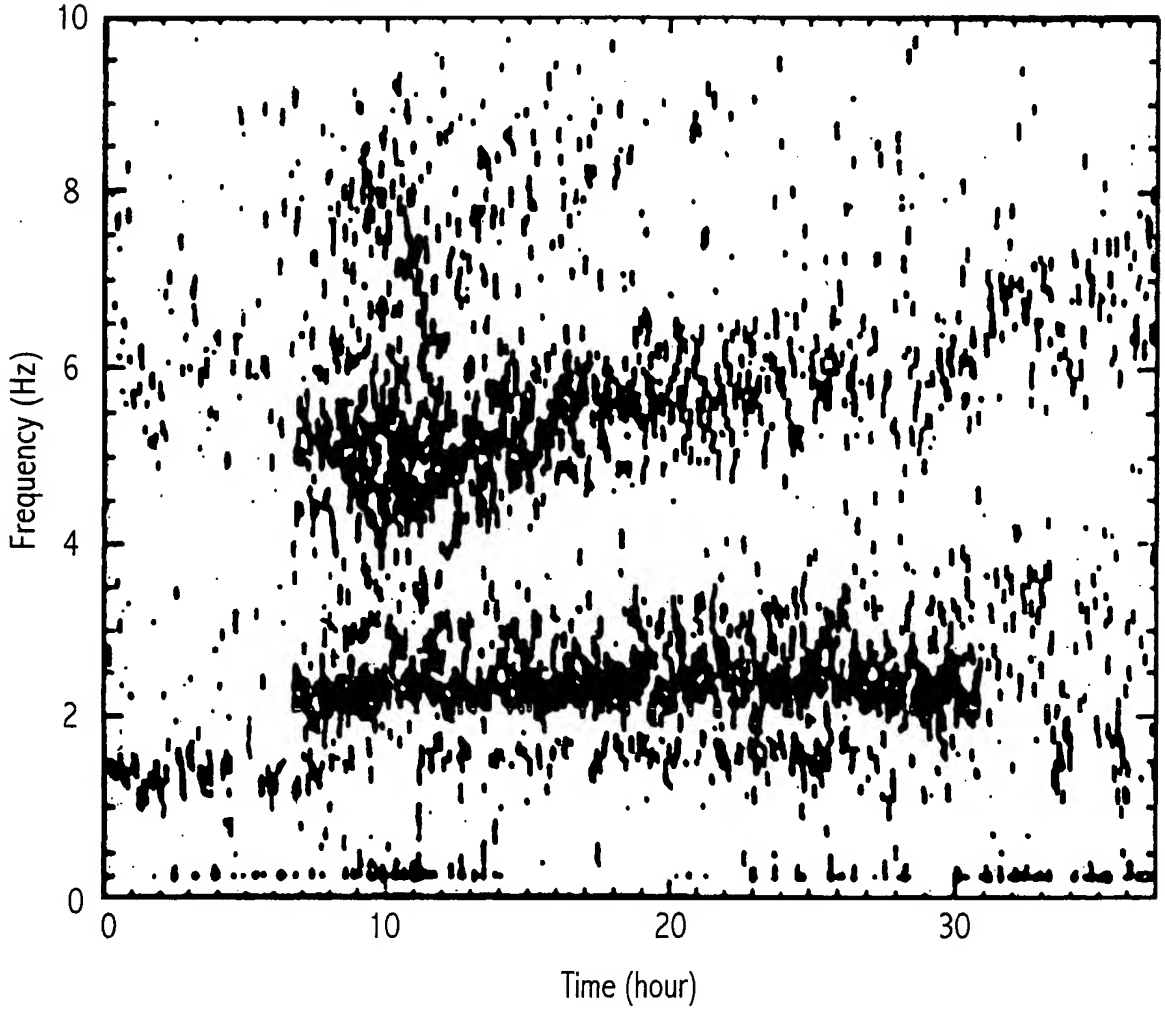


FIG. 24

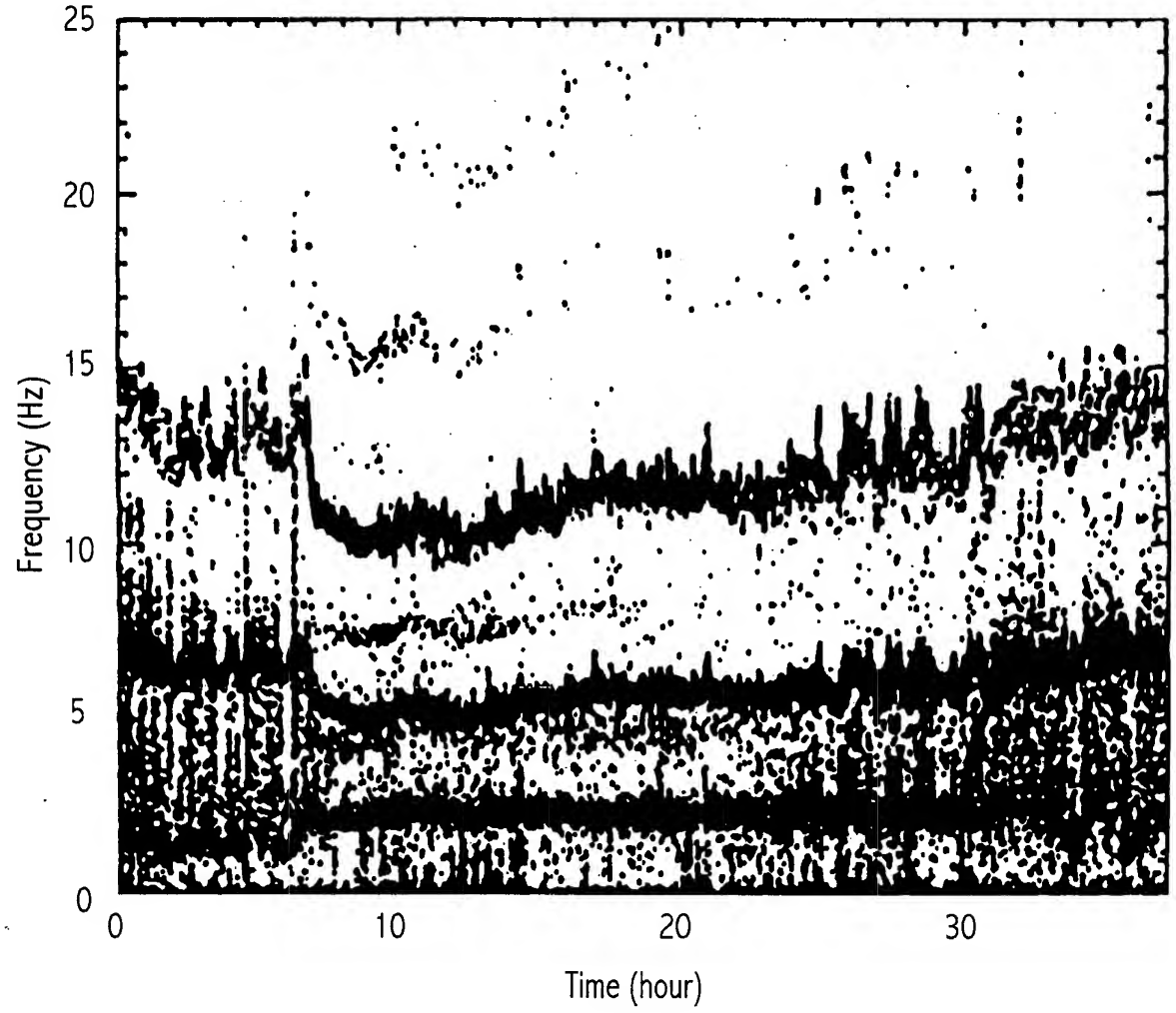


FIG. 25

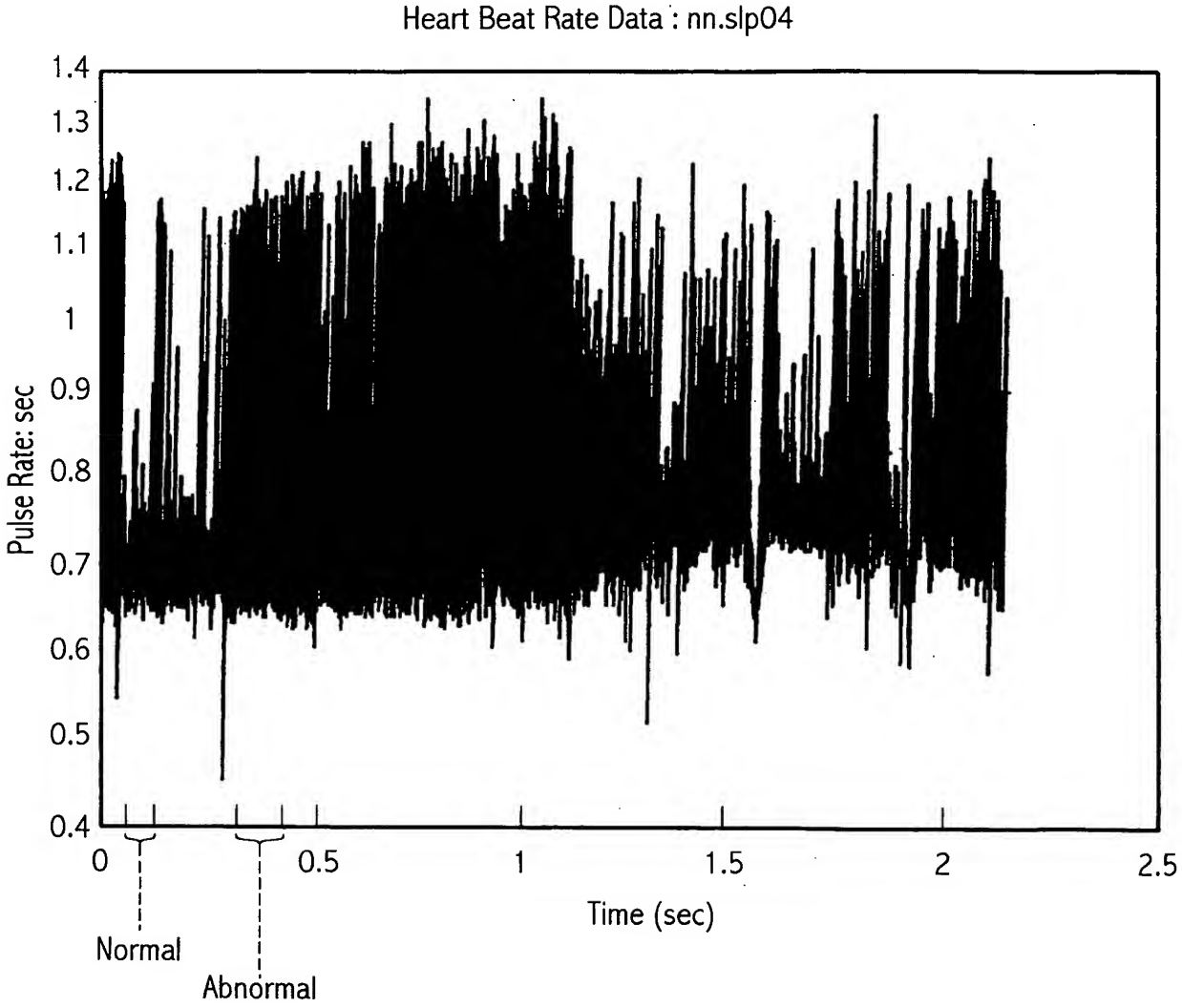

Heart Beat Rate Data : nn.slp04
Pulse Rate: sec
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0
0.5
1
1.5
2
2.5
Time (sec)
Normal
Abnormal

FIG. 26

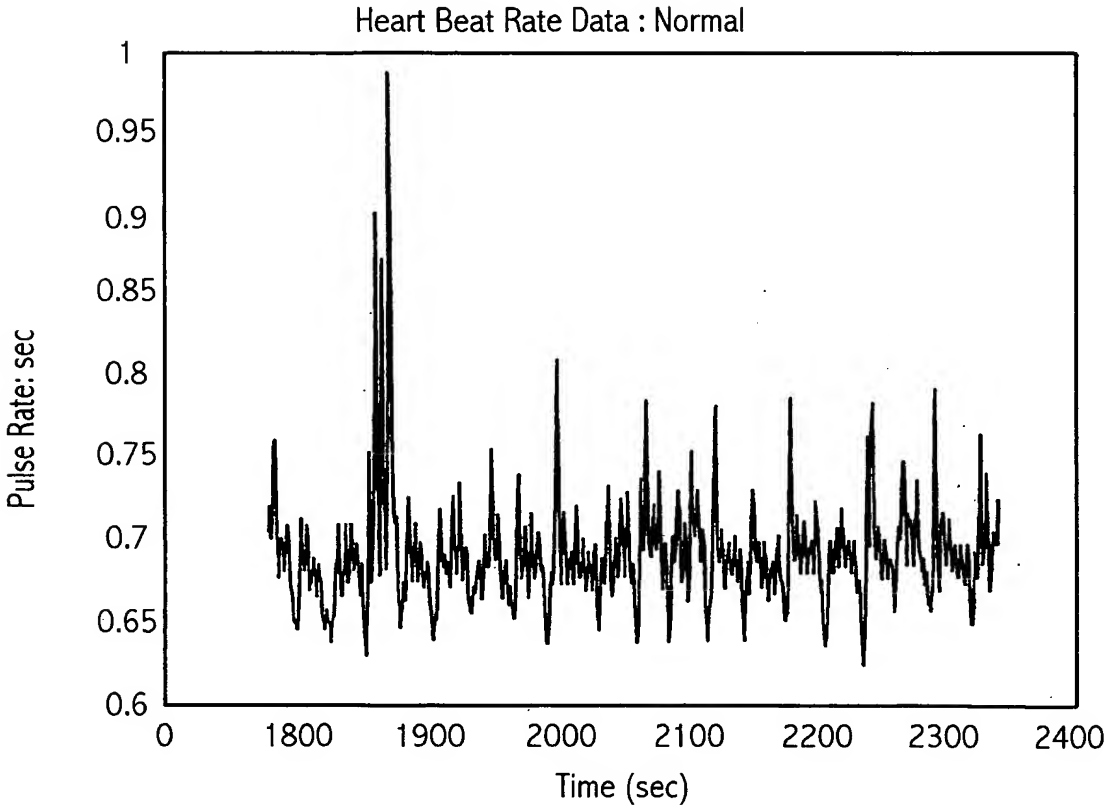

Heart Beat Rate Data : Normal
Pulse Rate: sec
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0
1800
1900
2000
2100
2200
2300
2400
Time (sec)

FIG. 27(a)

FIG. 27(b)

FIG. 27(c)

FIG. 27(d)

FIG. 27(e)

FIG. 27(f)

FIG. 27(g)

FIG. 27(h)

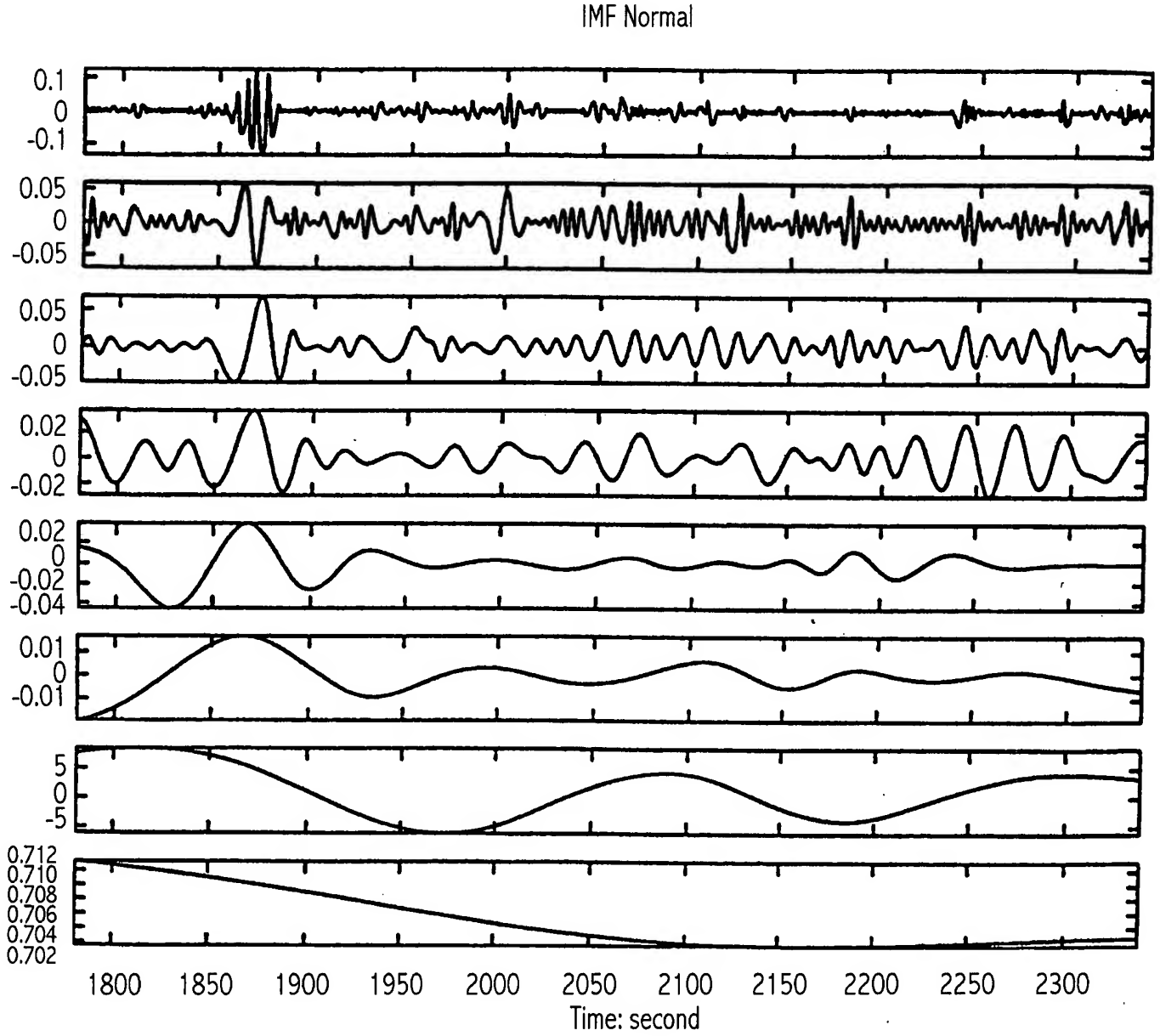


FIG. 28

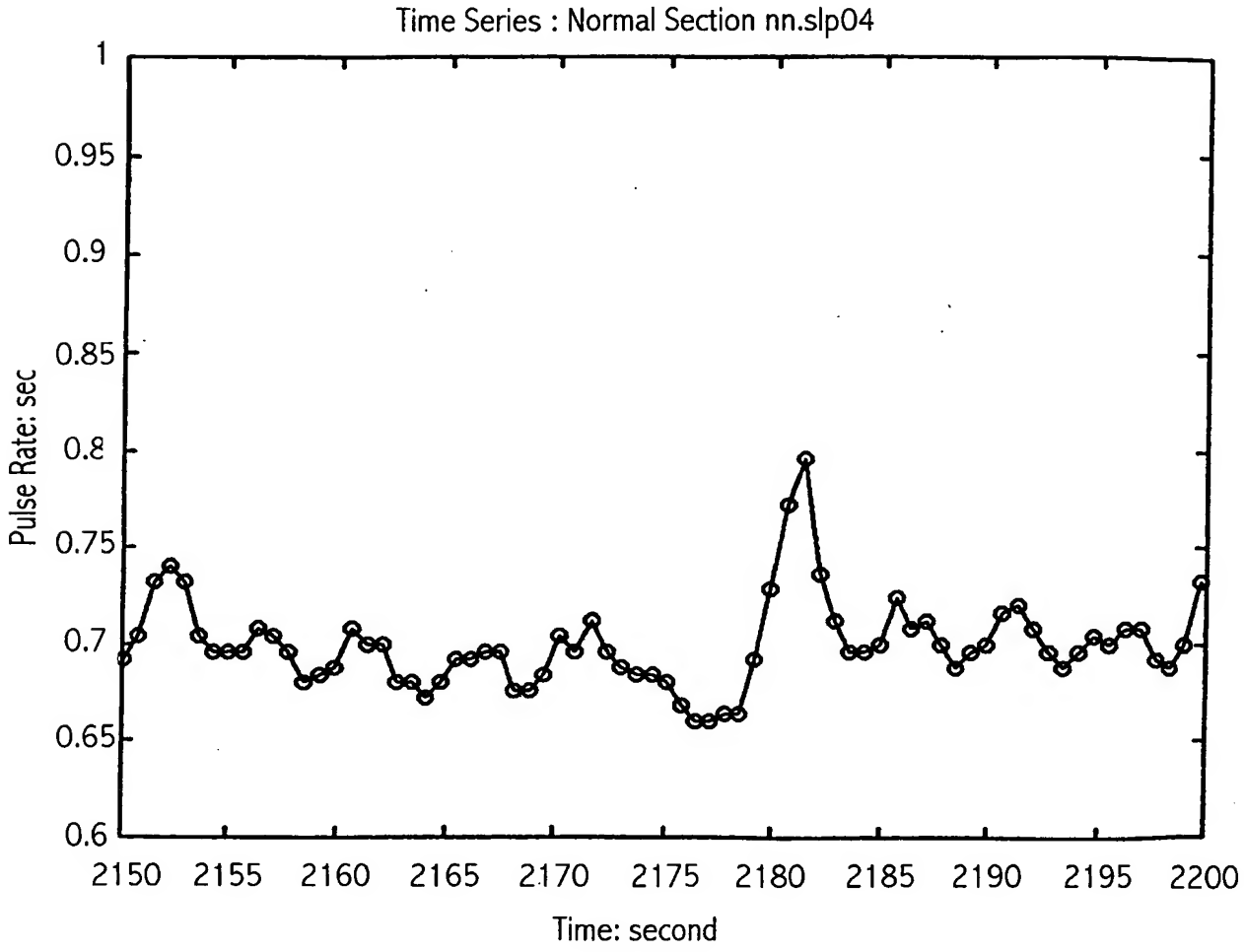

Time Series : Normal Section nn.slp04
Pulse Rate: sec
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
2150
2155
2160
2165
2170
2175
2180
2185
2190
2195
2200
Time: second

FIG. 29

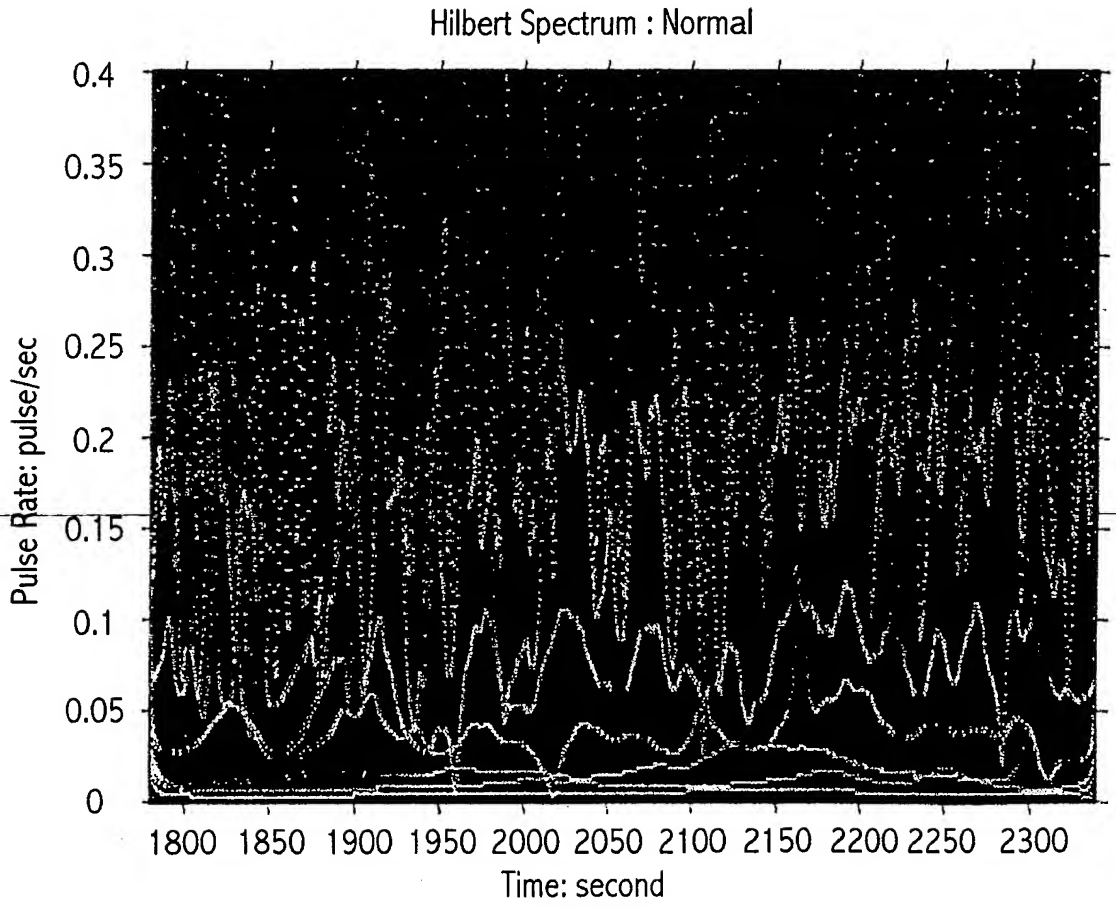
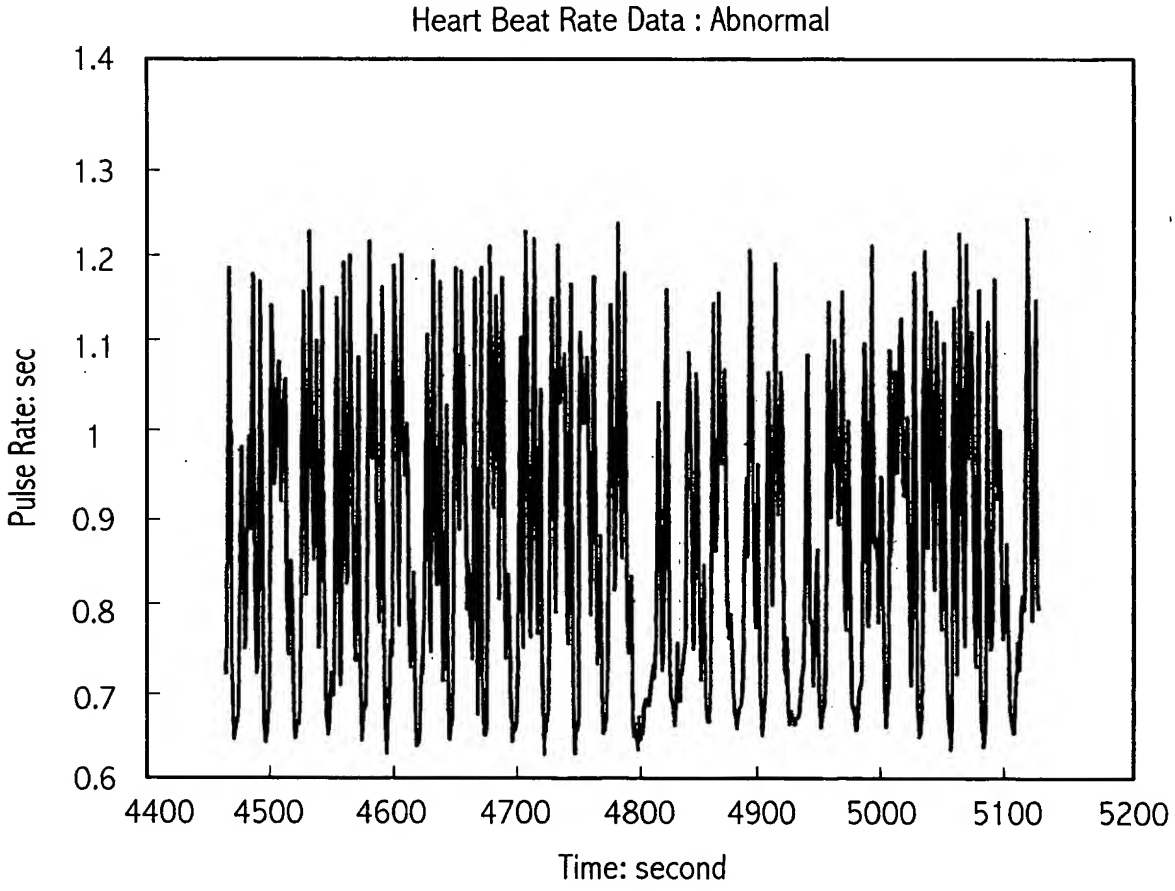

Hilbert Spectrum : Normal
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Pulse Rate: pulse/sec
1800 1850 1900 1950 2000 2050 2100 2150 2200 2250 2300
Time: second

FIG. 30


Heart Beat Rate Data : Abnormal
Pulse Rate: sec
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
4400
4500
4600
4700
4800
4900
5000
5100
5200
Time: second

20210302_256E2001

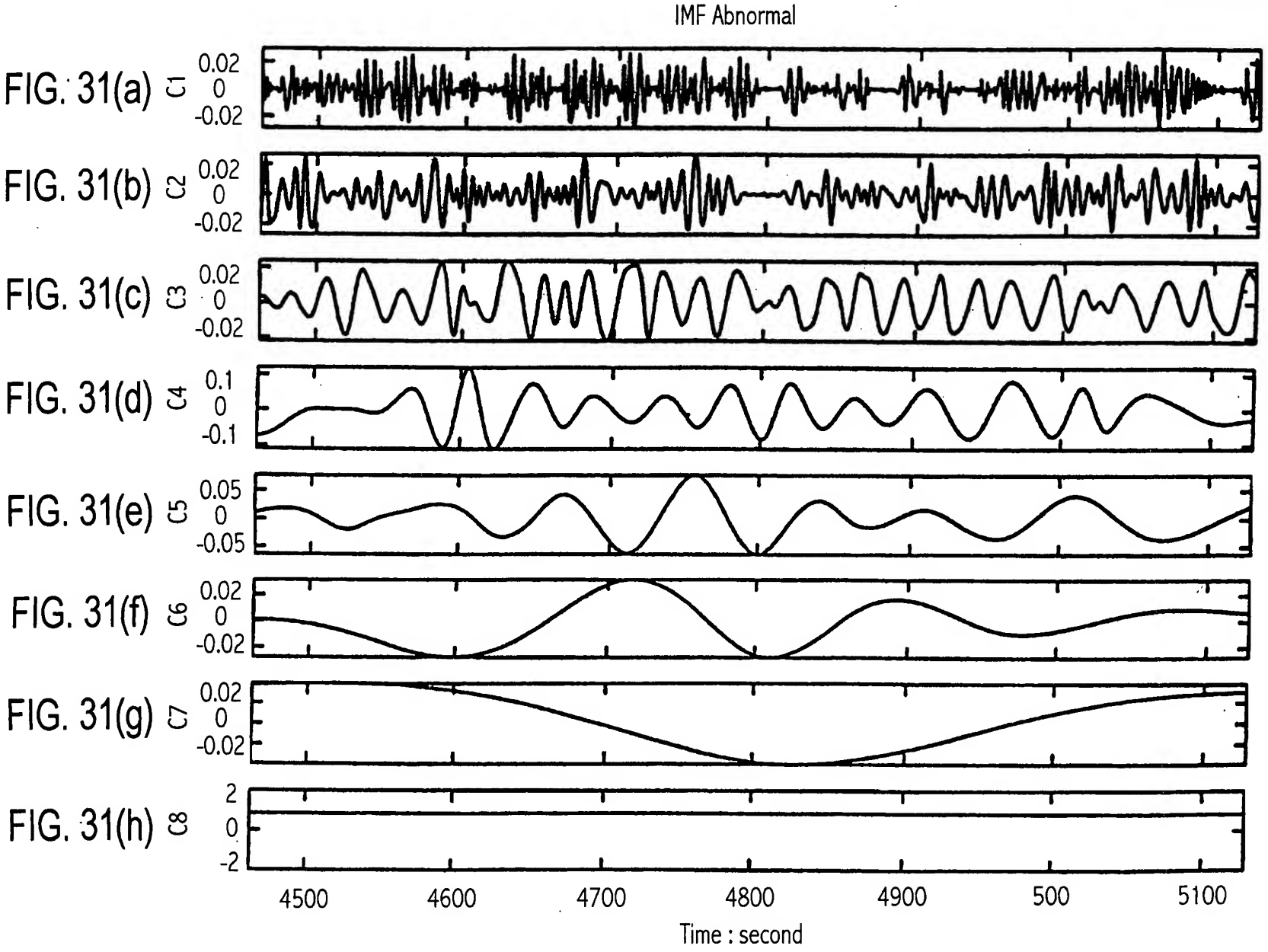


FIG. 31(a)

FIG. 31(b)

FIG. 31(c)

FIG. 31(d)

FIG. 31(e)

FIG. 31(f)

FIG. 31(g)

FIG. 31(h)

FIG. 32

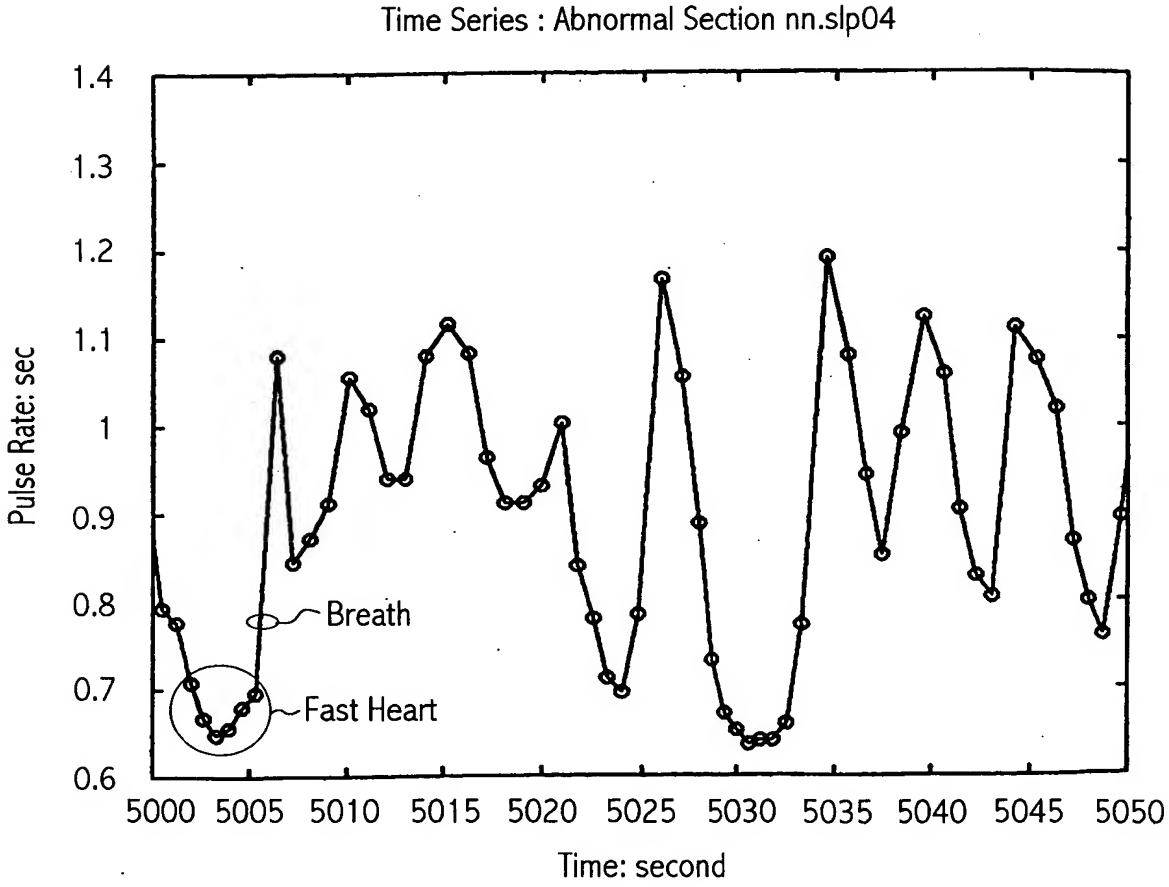

Time Series : Abnormal Section nn.slp04
Pulse Rate: sec
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
Breath
Fast Heart
5000 5005 5010 5015 5020 5025 5030 5035 5040 5045 5050
Time: second

FIG. 33

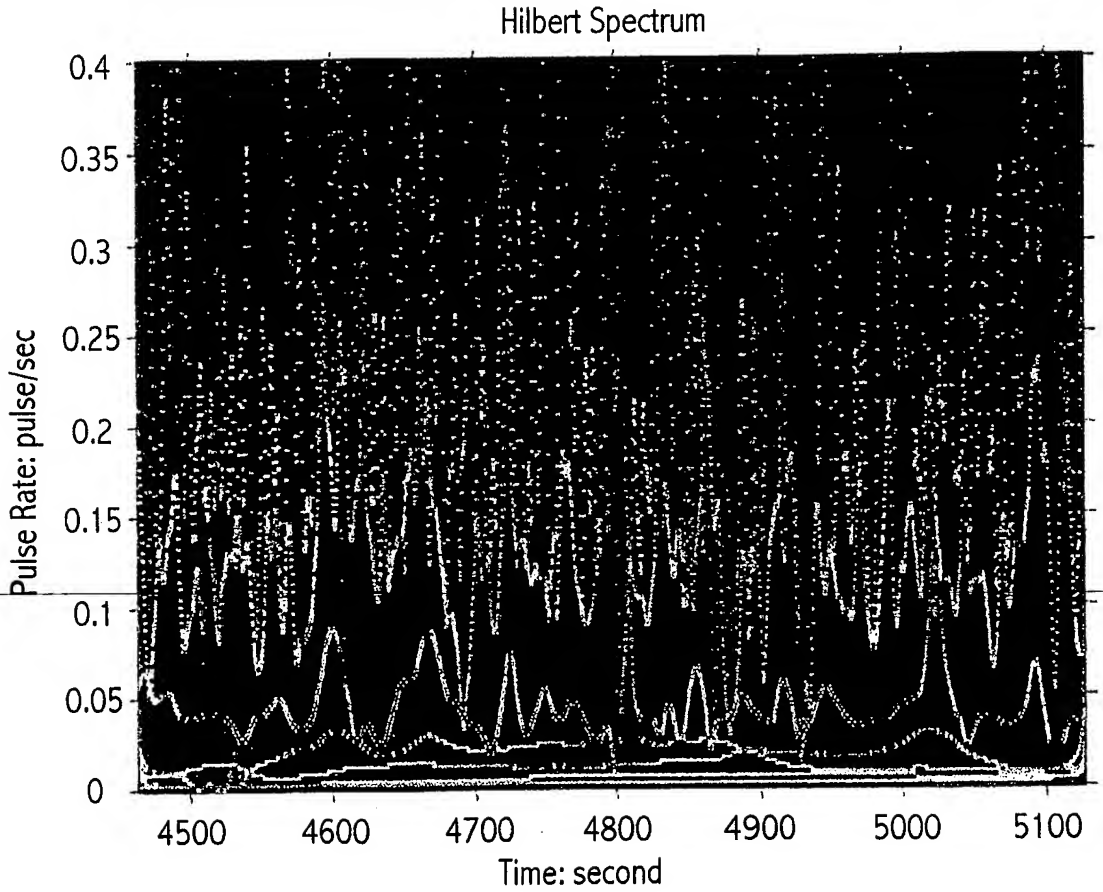

Hilbert Spectrum
Pulse Rate: pulse/sec
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
4500
4600
4700
4800
4900
5000
5100
Time: second

FIG. 34

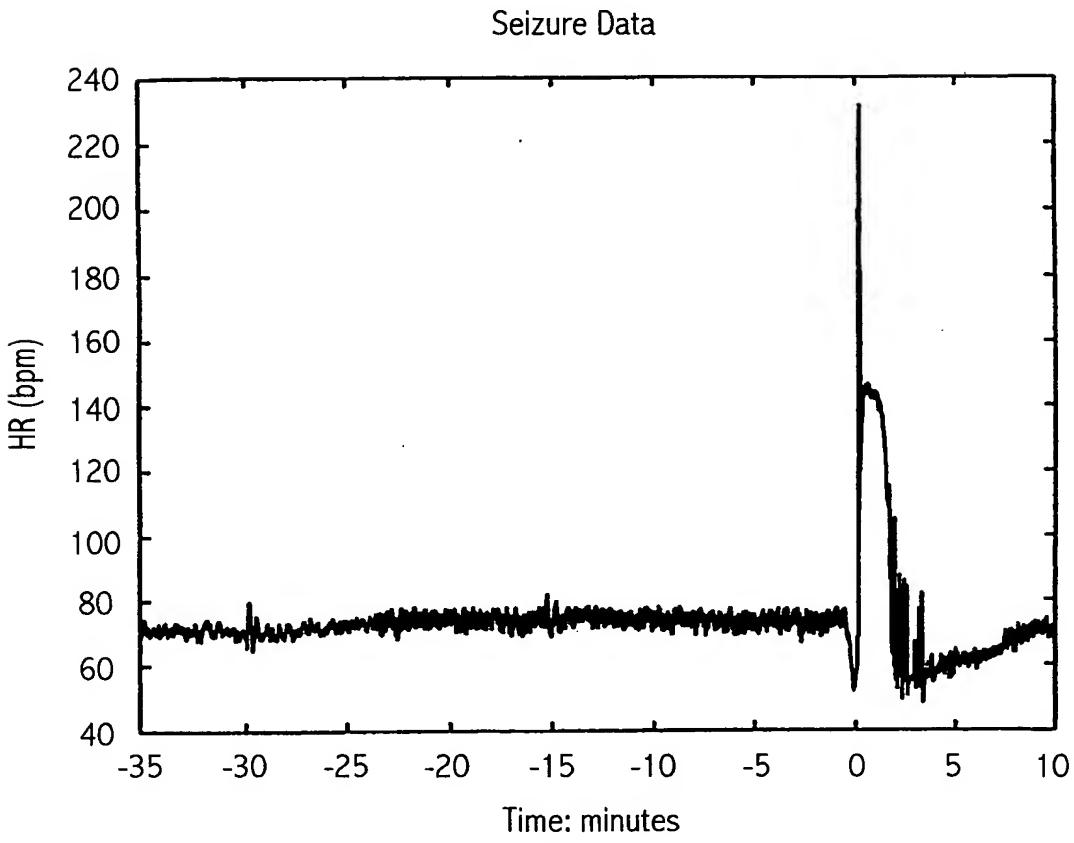

Seizure Data
240
220
200
180
160
140
120
100
80
60
40
HR (bpm)
-35
-30
-25
-20
-15
-10
-5
0
5
10
Time: minutes

FIG. 35(a)

FIG. 35(b)

FIG. 35(c)

FIG. 35(d)

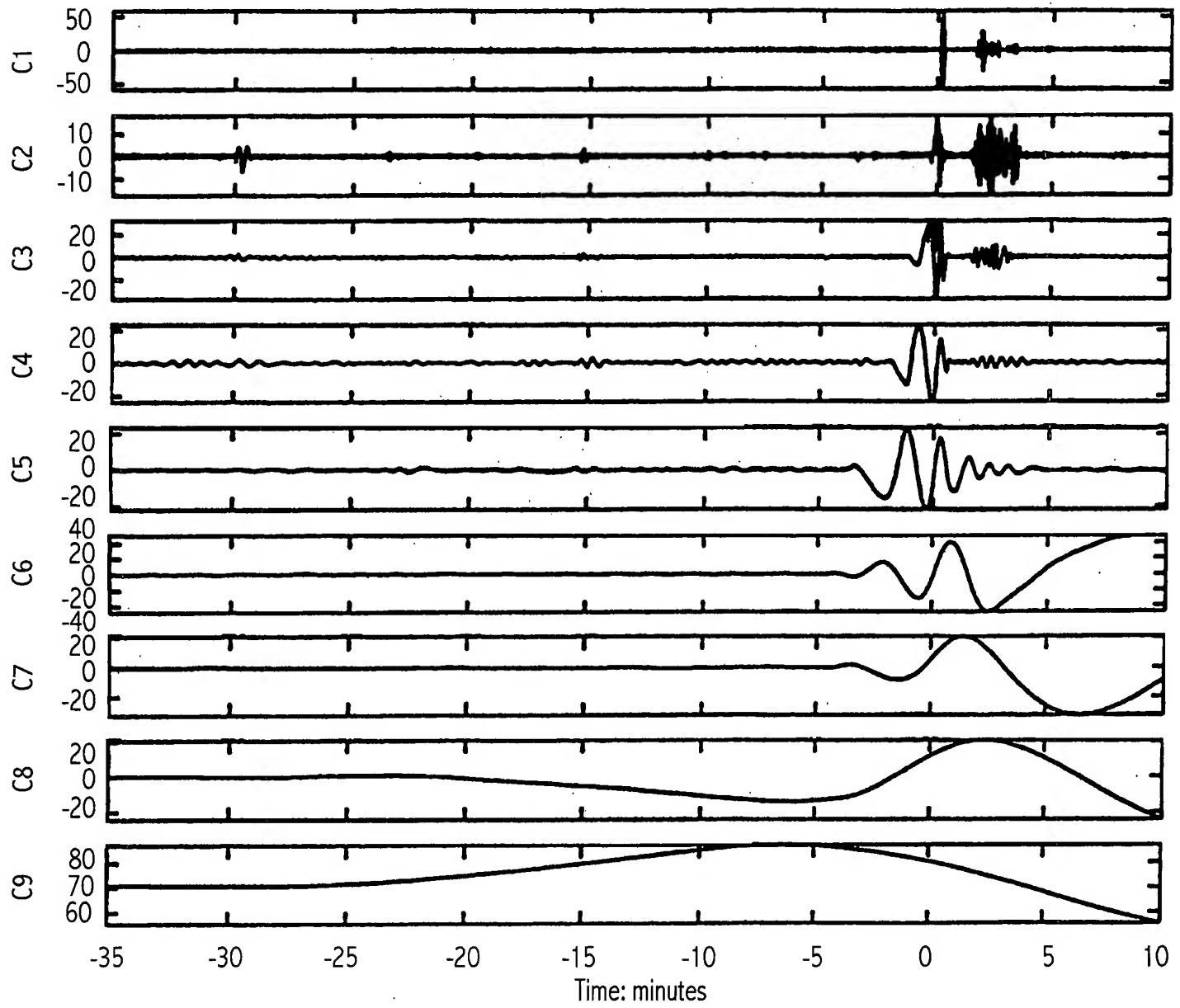
FIG. 35(e)

FIG. 35(f)

FIG. 35(g)

FIG. 35(h)

FIG. 35(i)



Intrinsic Mode Decomposition

FIG. 36(a)

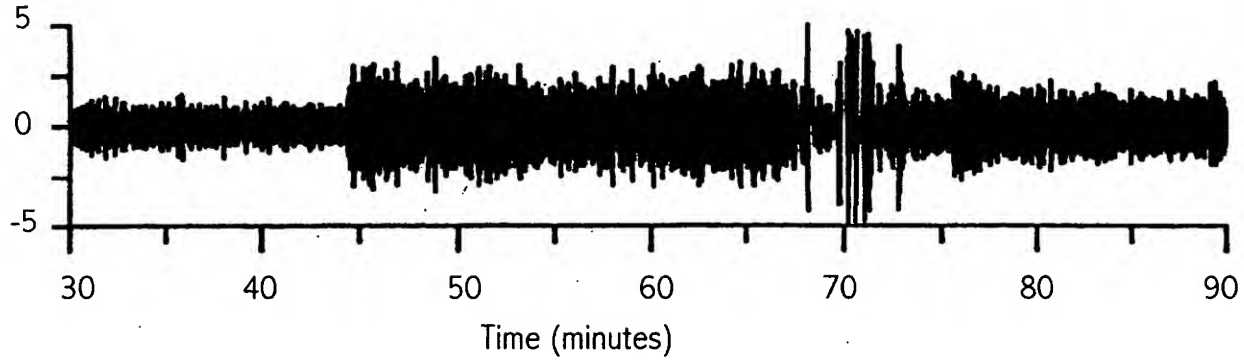


FIG. 36(b)

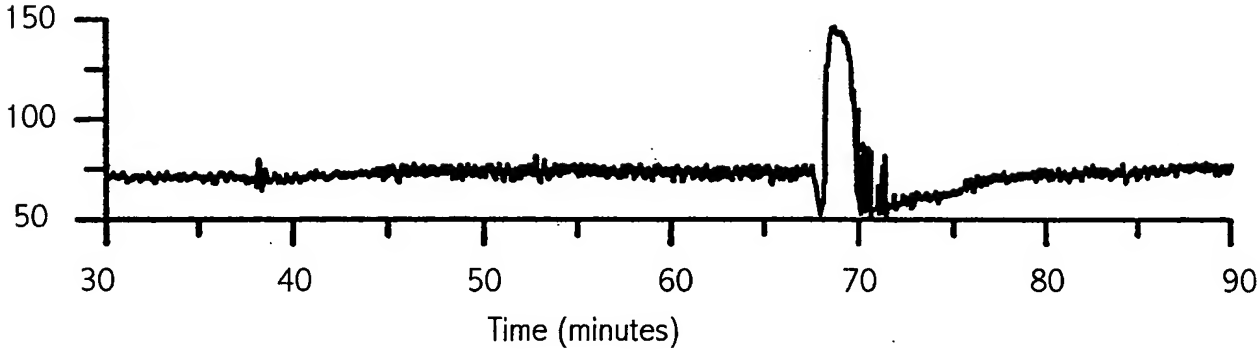


FIG. 36(c)

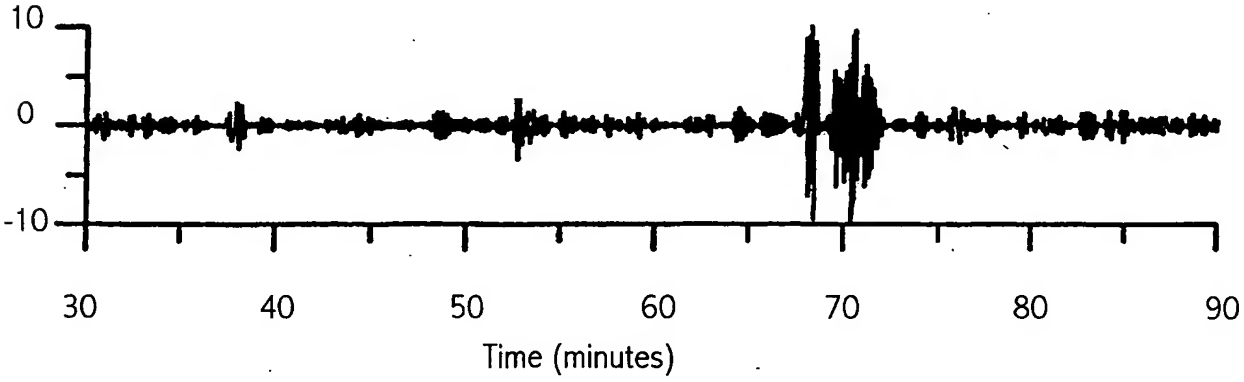


FIG. 37

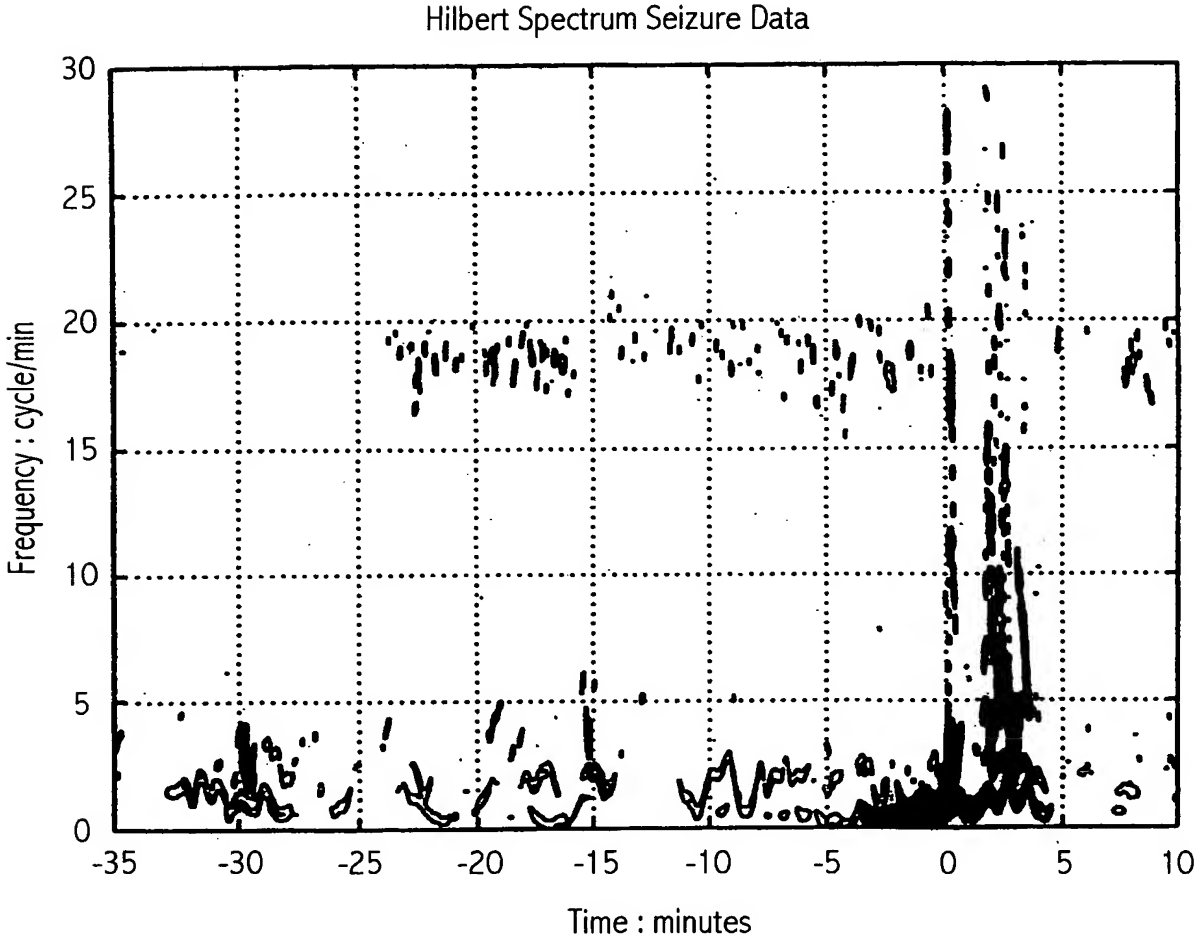
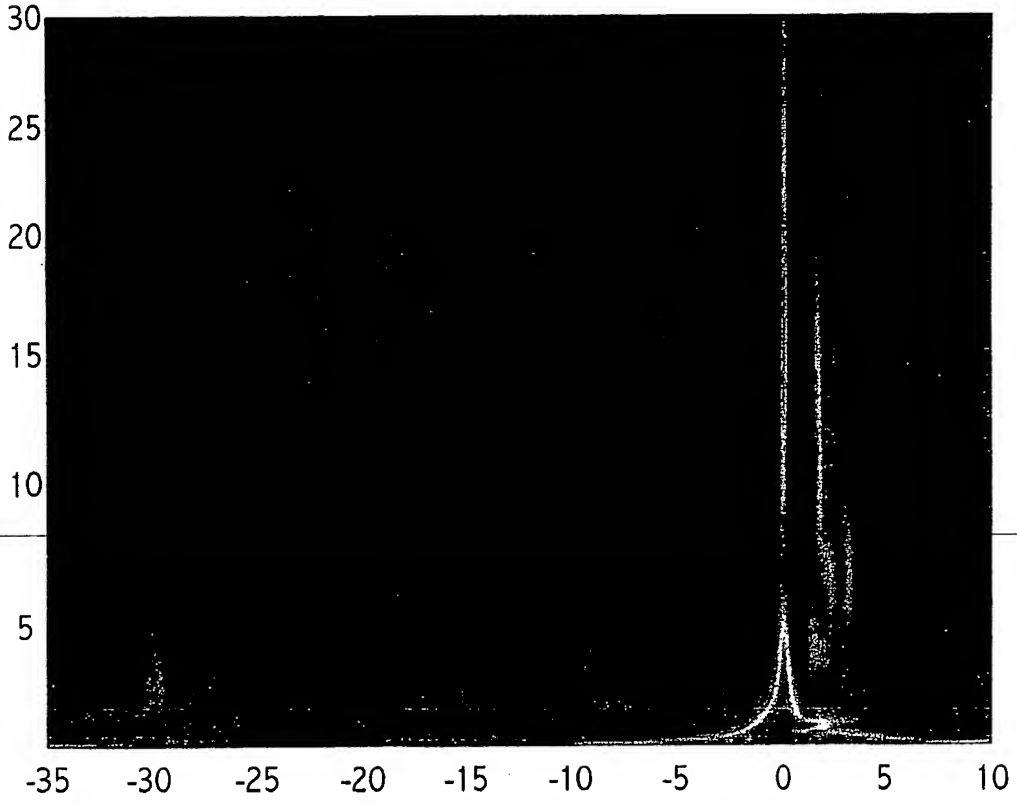

Hilbert Spectrum Seizure Data
Frequency : cycle/min
30
25
20
15
10
5
0
-35
-30
-25
-20
-15
-10
-5
0
5
10
Time : minutes

FIG. 38



20070129 1556203

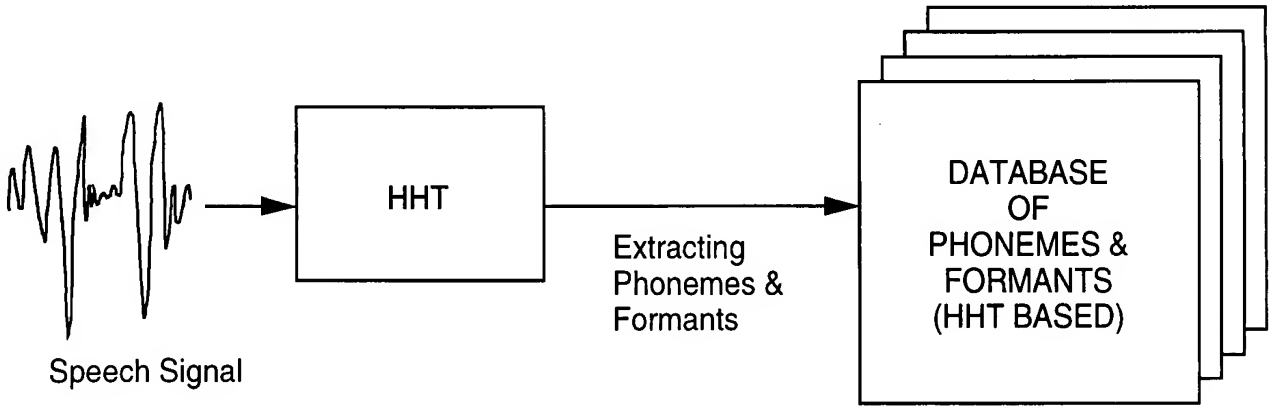


FIG. 39

3967399 2002001

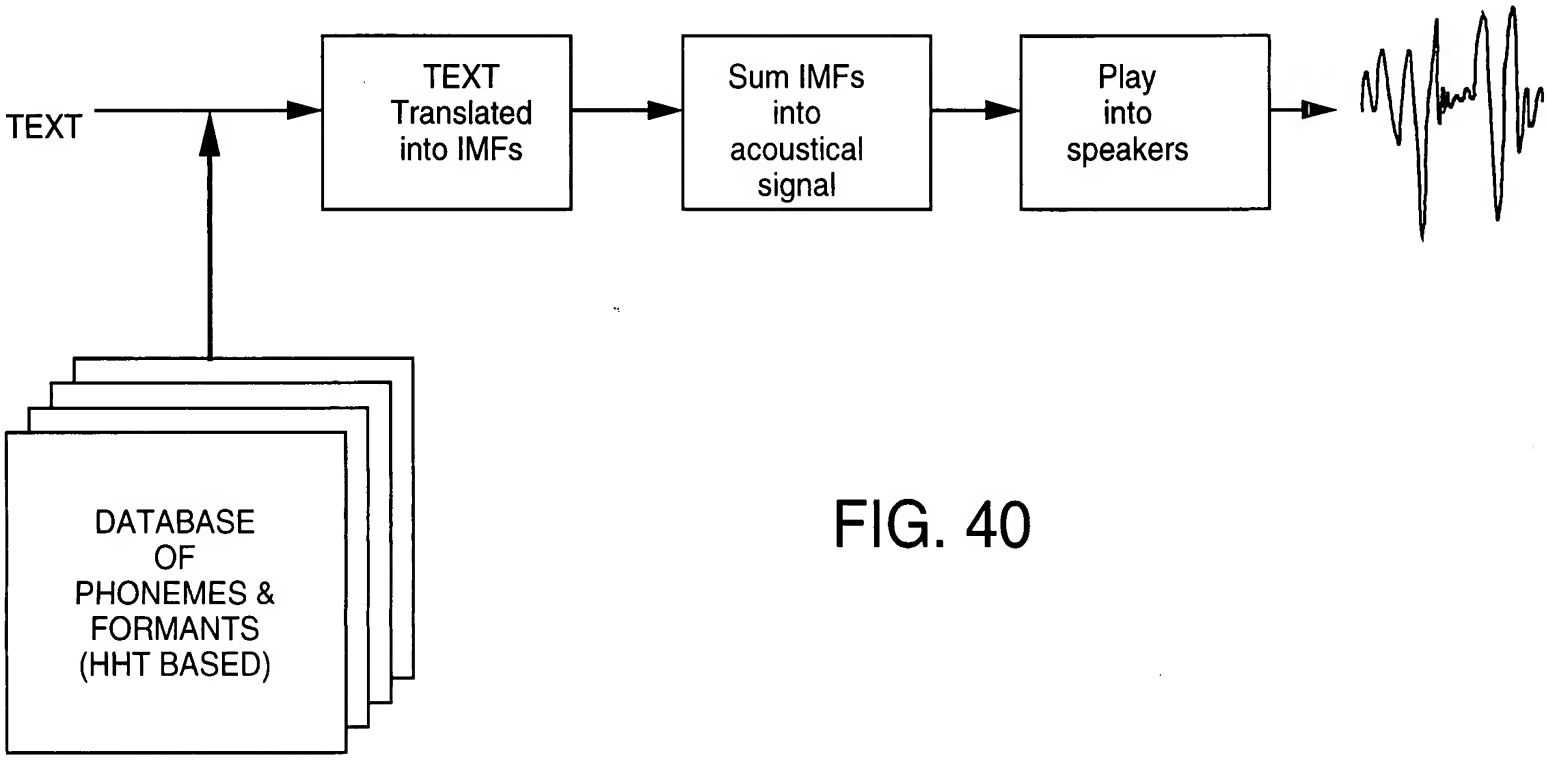


FIG. 40

3825289 "2562097

FIG. 41

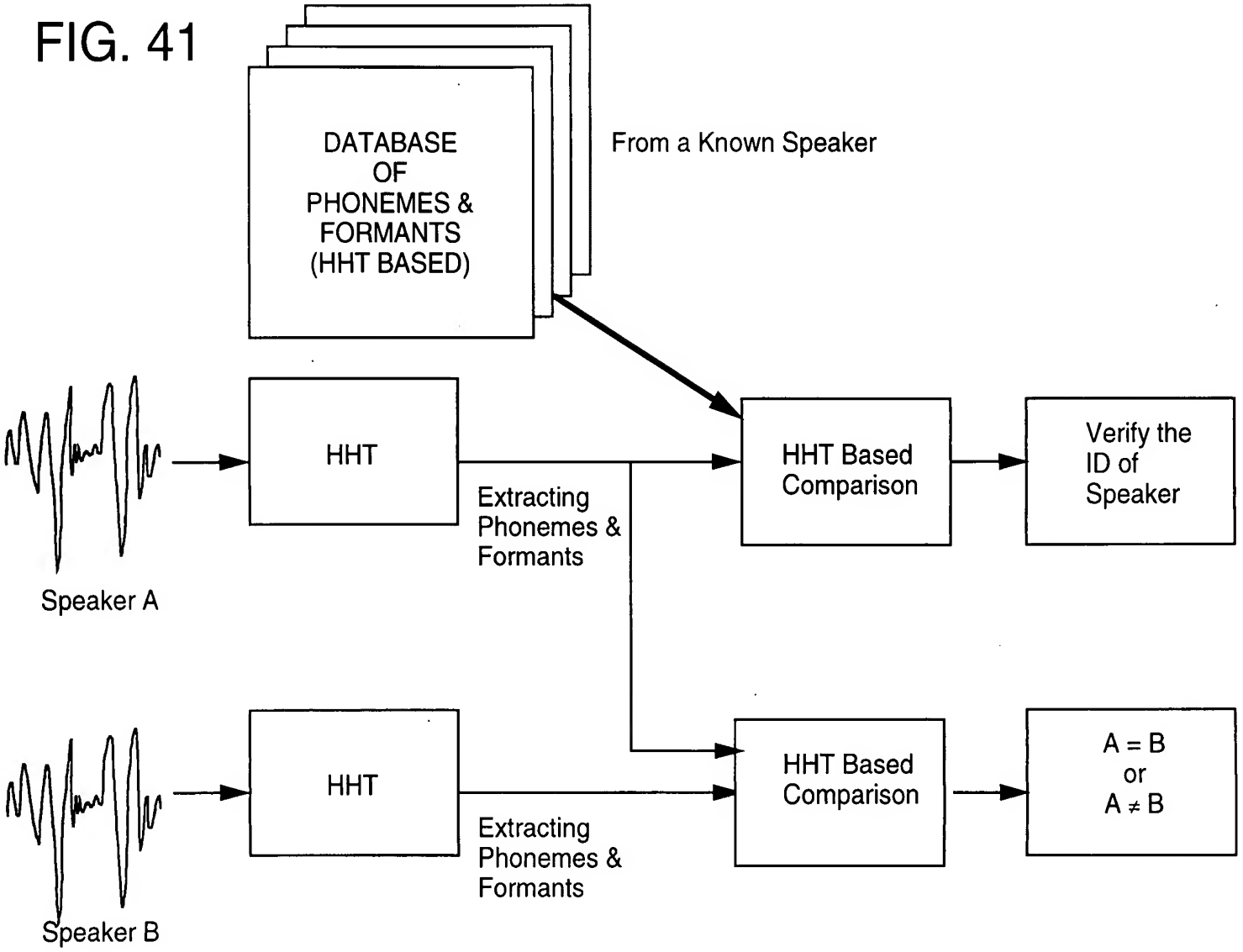
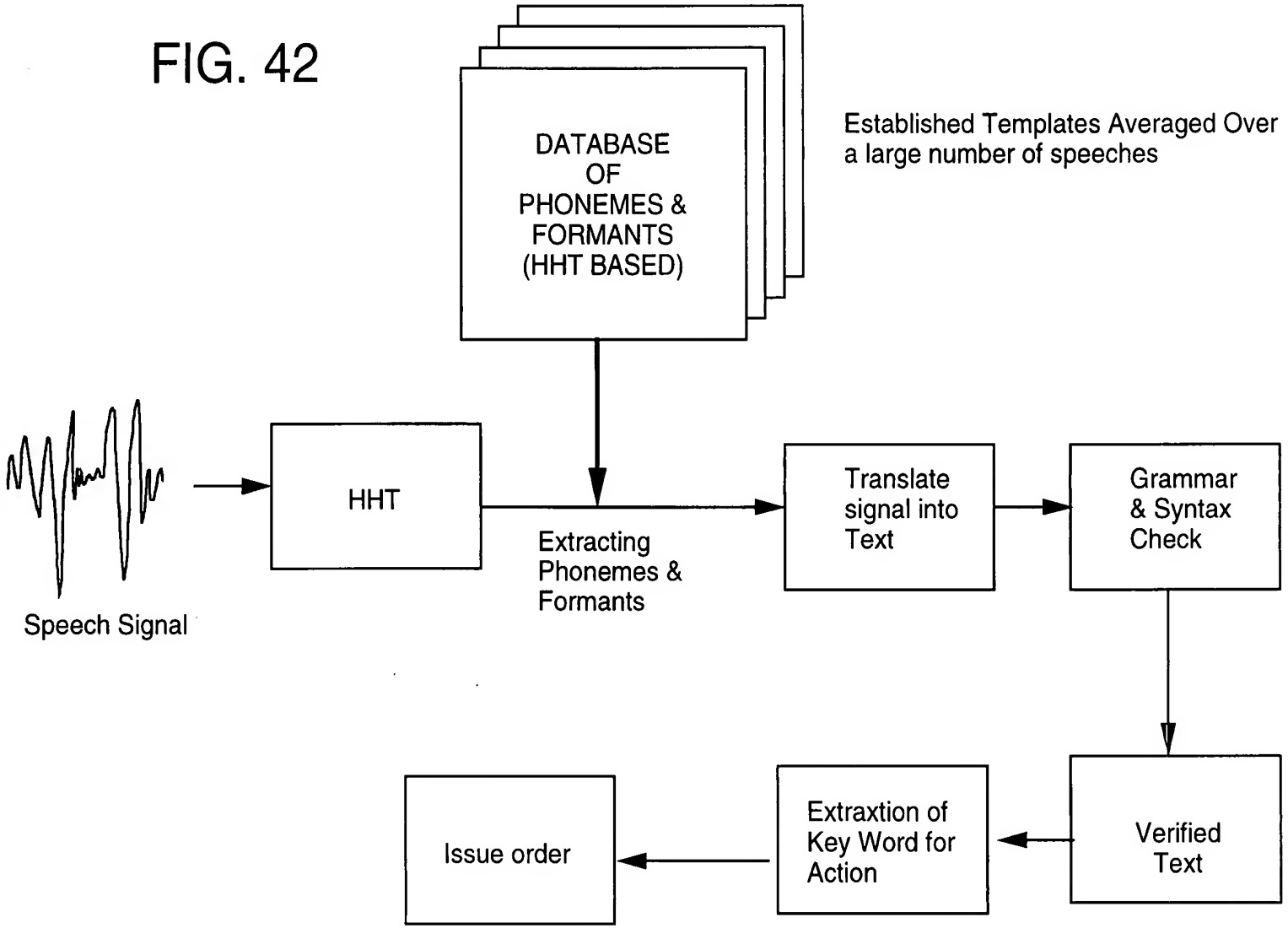


FIG. 42


DATABASE
OF
PHONEMES &
FORMANTS
(HHT BASED)
Established Templates Averaged Over
a large number of speeches
HHT
Extracting
Phonemes &
Formants
Translate
signal into
Text
Grammar
& Syntax
Check
Speech Signal
Issue order
Extraxtion of
Key Word for
Action
Verified
Text

20070925.2362097

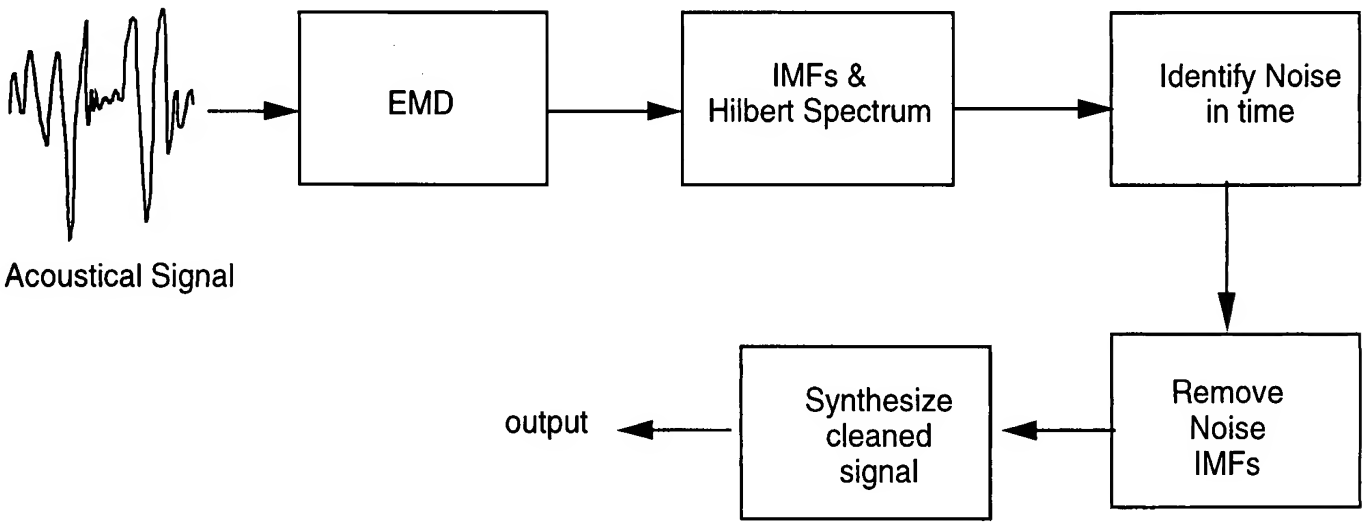


FIG. 43

20020730 2582697

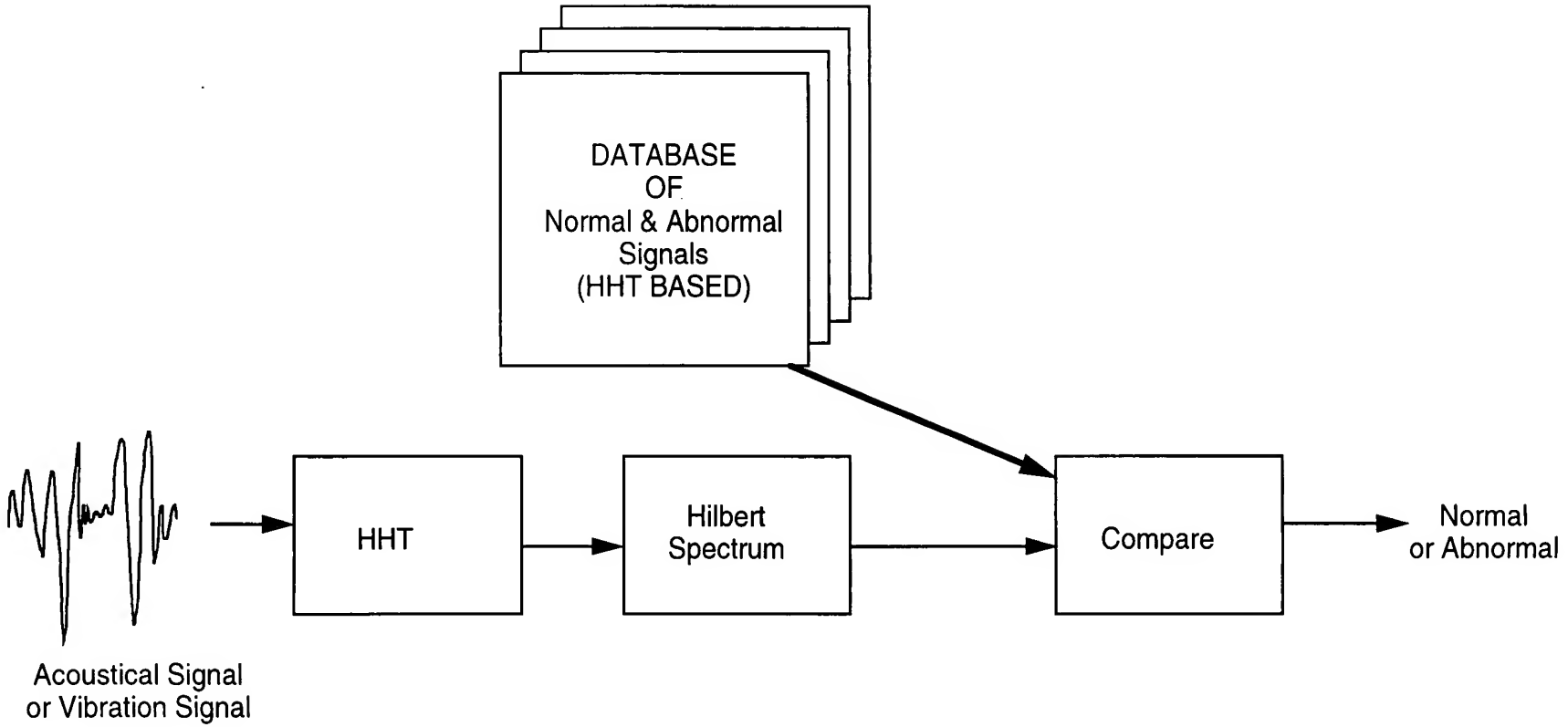


FIG. 44

FIG. 45(a)

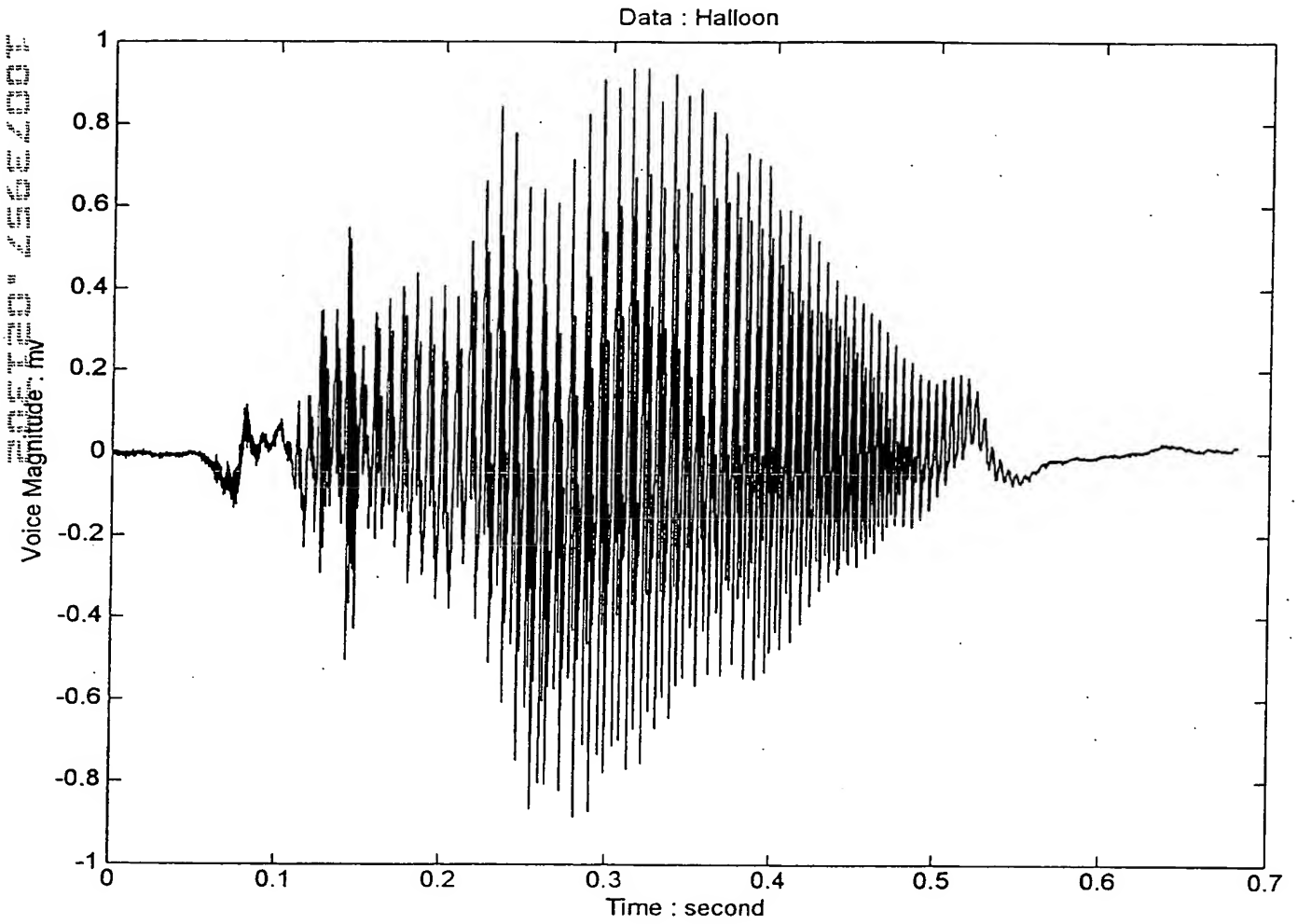

Data : Halloon
Voice Magnitude : mv
Time : second
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

FIG. 45(b)

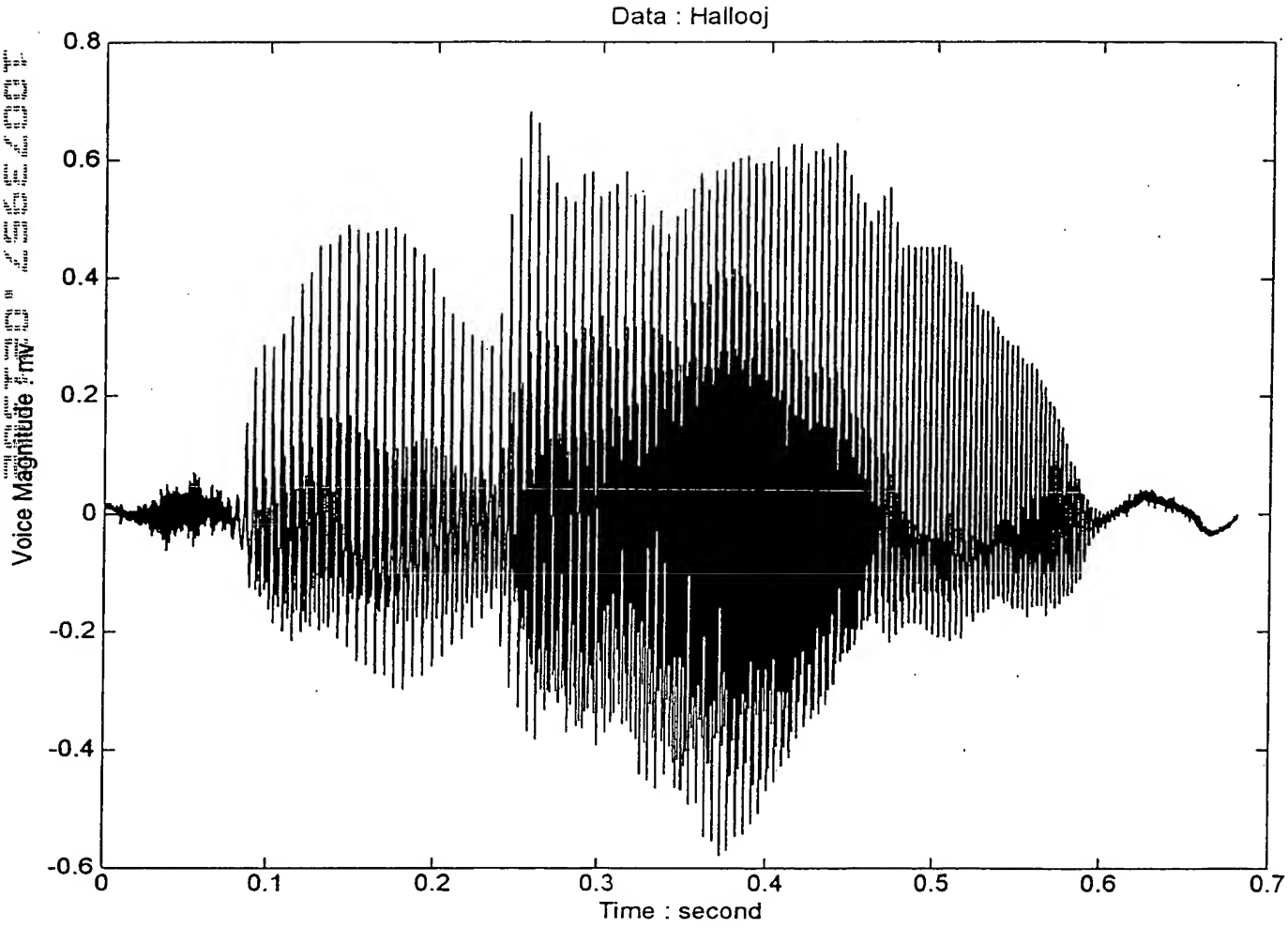

Data : Hallooj
Voice Magnitude : mV
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Time : second

FIG. 46(a)

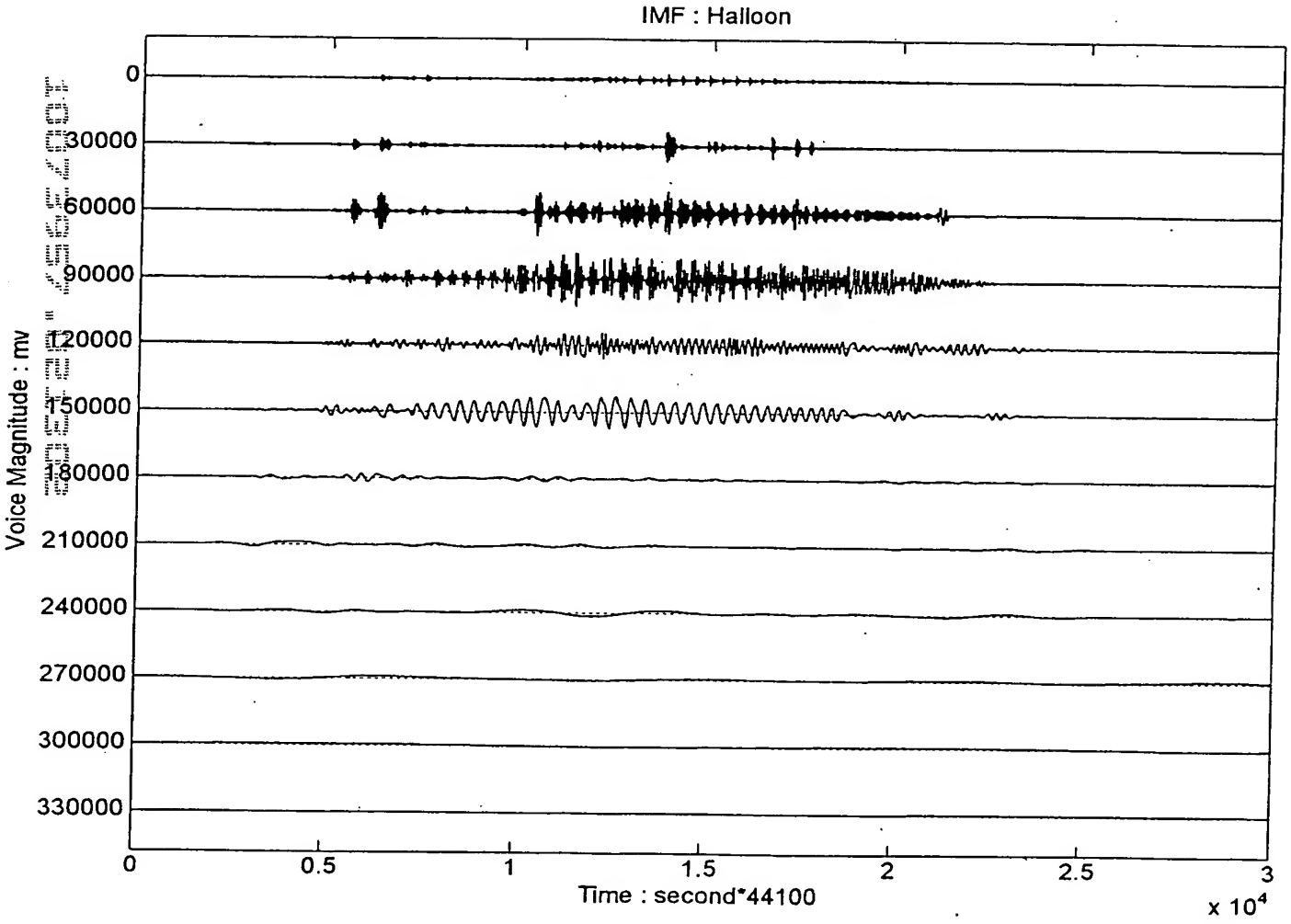

IMF : Halloon
Voice Magnitude : mv
0
30000
60000
90000
120000
150000
180000
210000
240000
270000
300000
330000
0
0.5
1
1.5
2
2.5
3
Time : second*44100
x 10^4

FIG. 46(b)

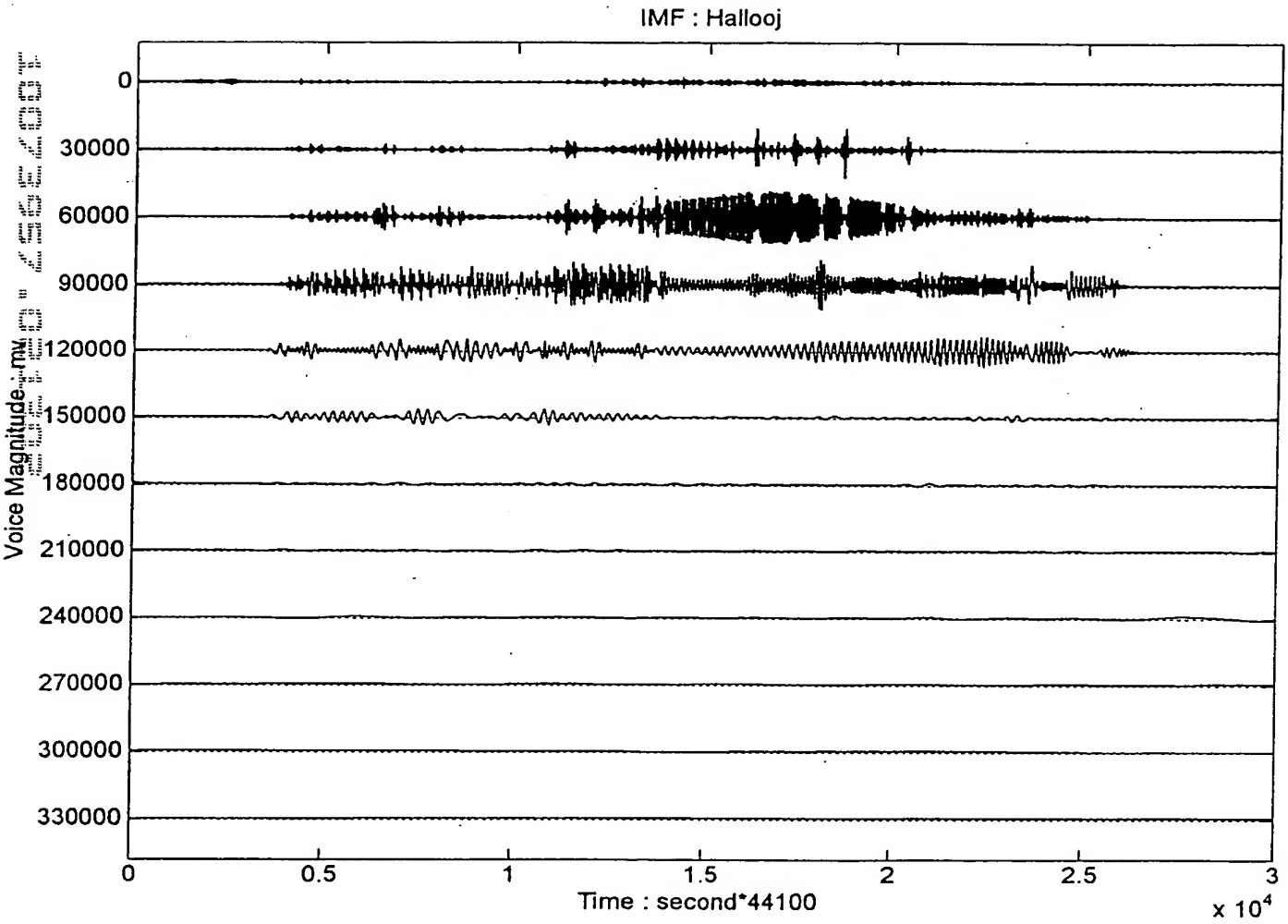

IMF : Hallooj
Voice Magnitude : mv
0
30000
60000
90000
120000
150000
180000
210000
240000
270000
300000
330000
0
0.5
1
1.5
2
2.5
3
Time : second*44100
x 10^4

FIG. 47(a)

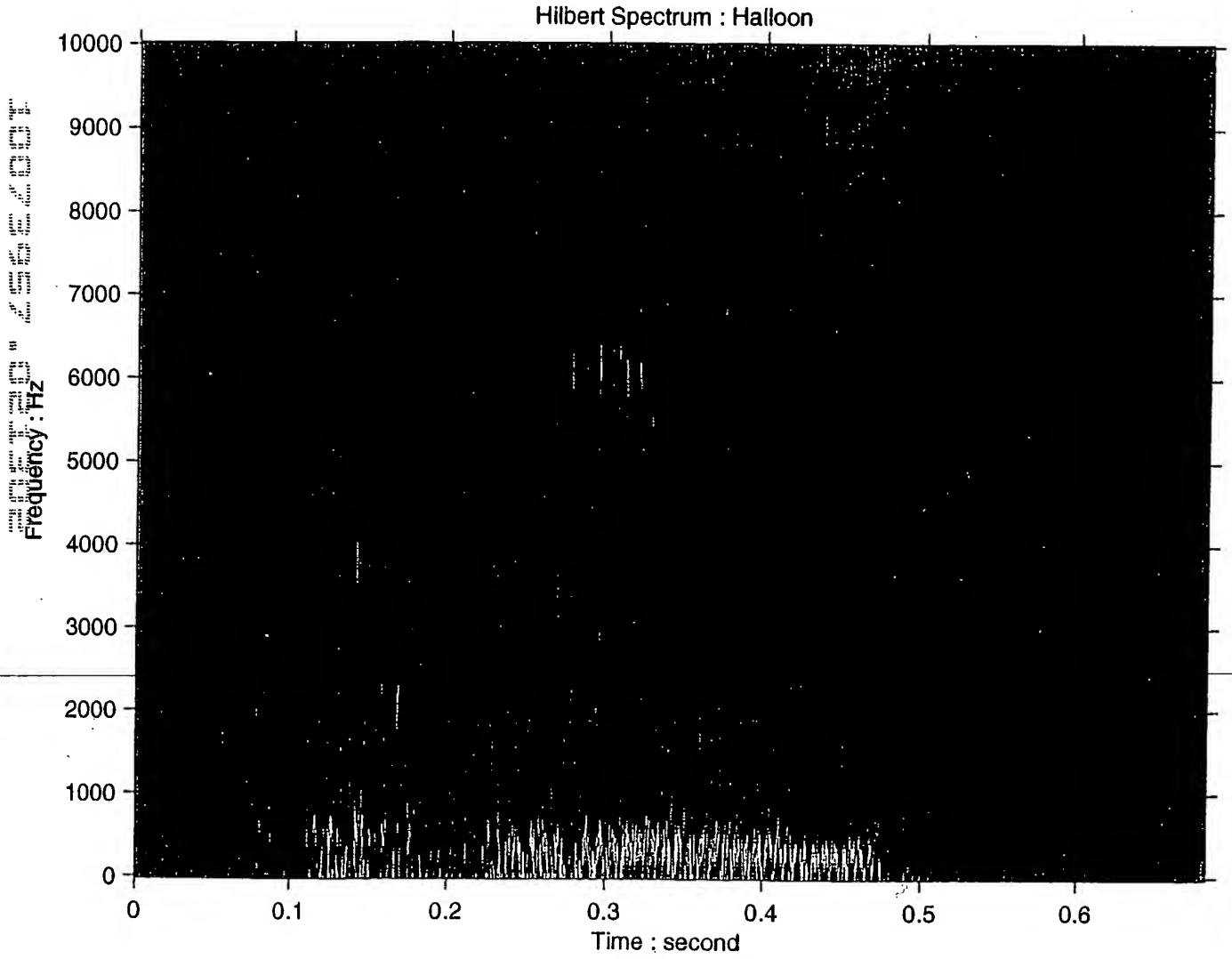

Hilbert Spectrum : Halloon
Frequency : Hz
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 47(b)

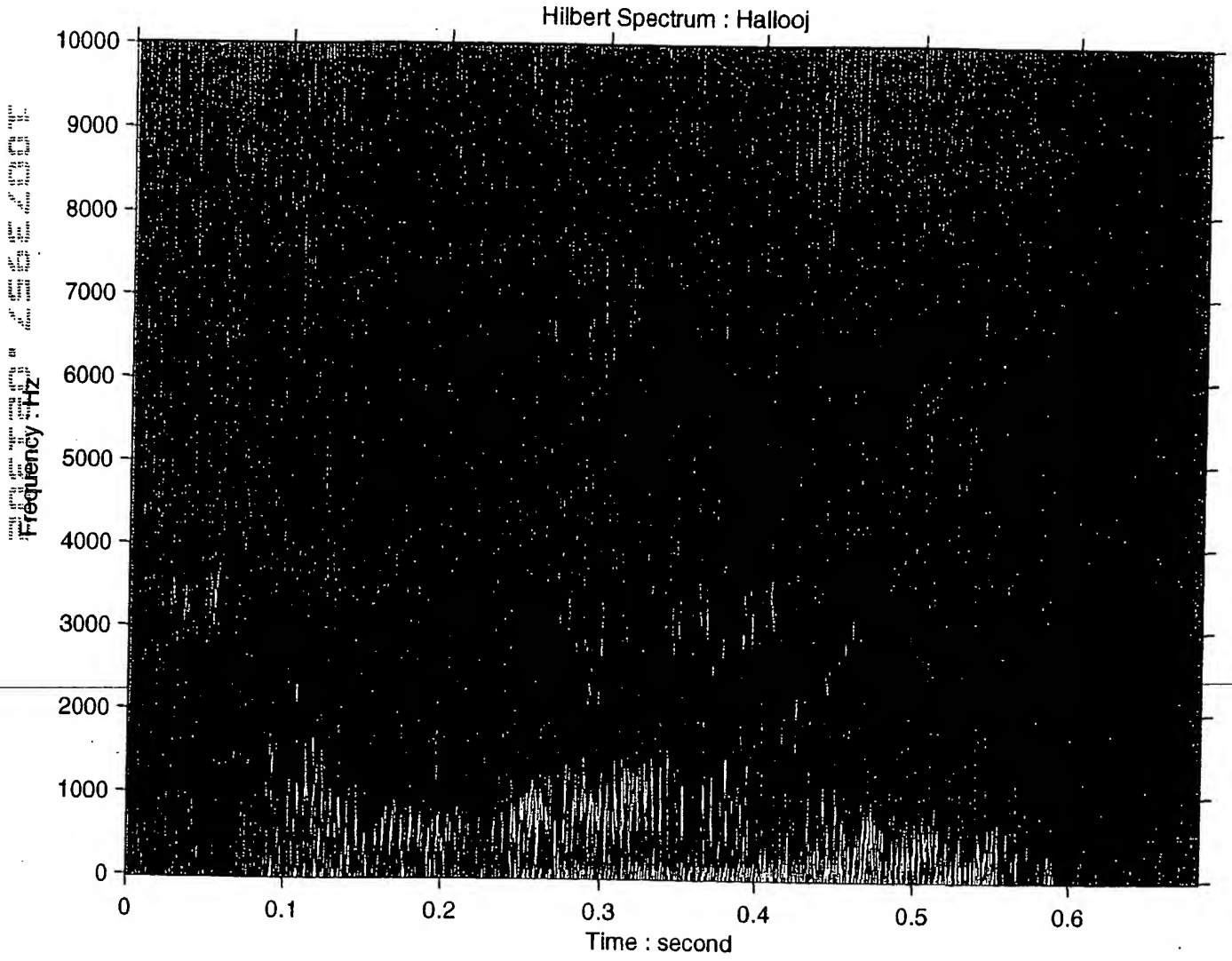

Hilbert Spectrum : Hallooj
Frequency : Hz
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 48(a)

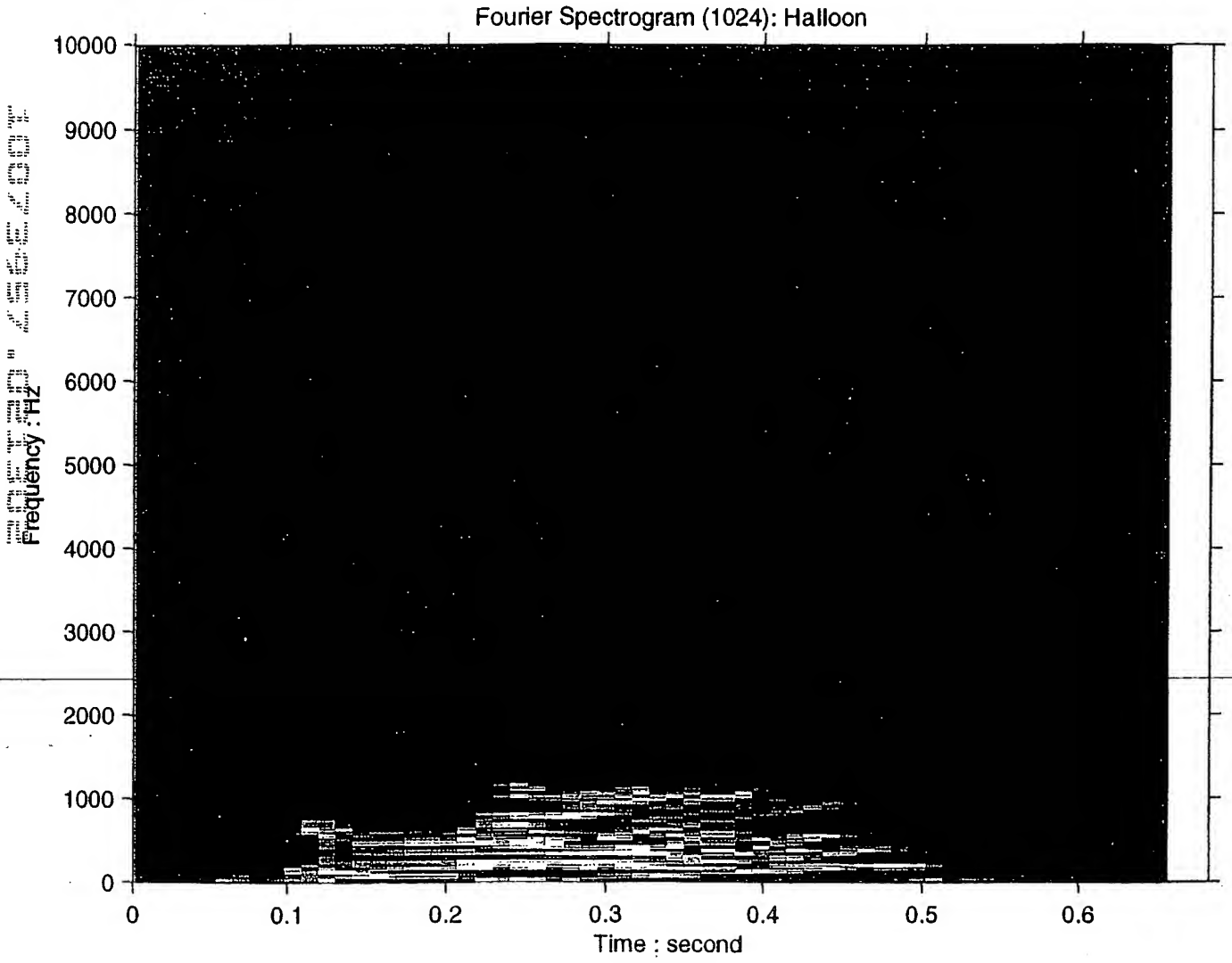

Fourier Spectrogram (1024): Halloon
Frequency : Hz
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 48(b)

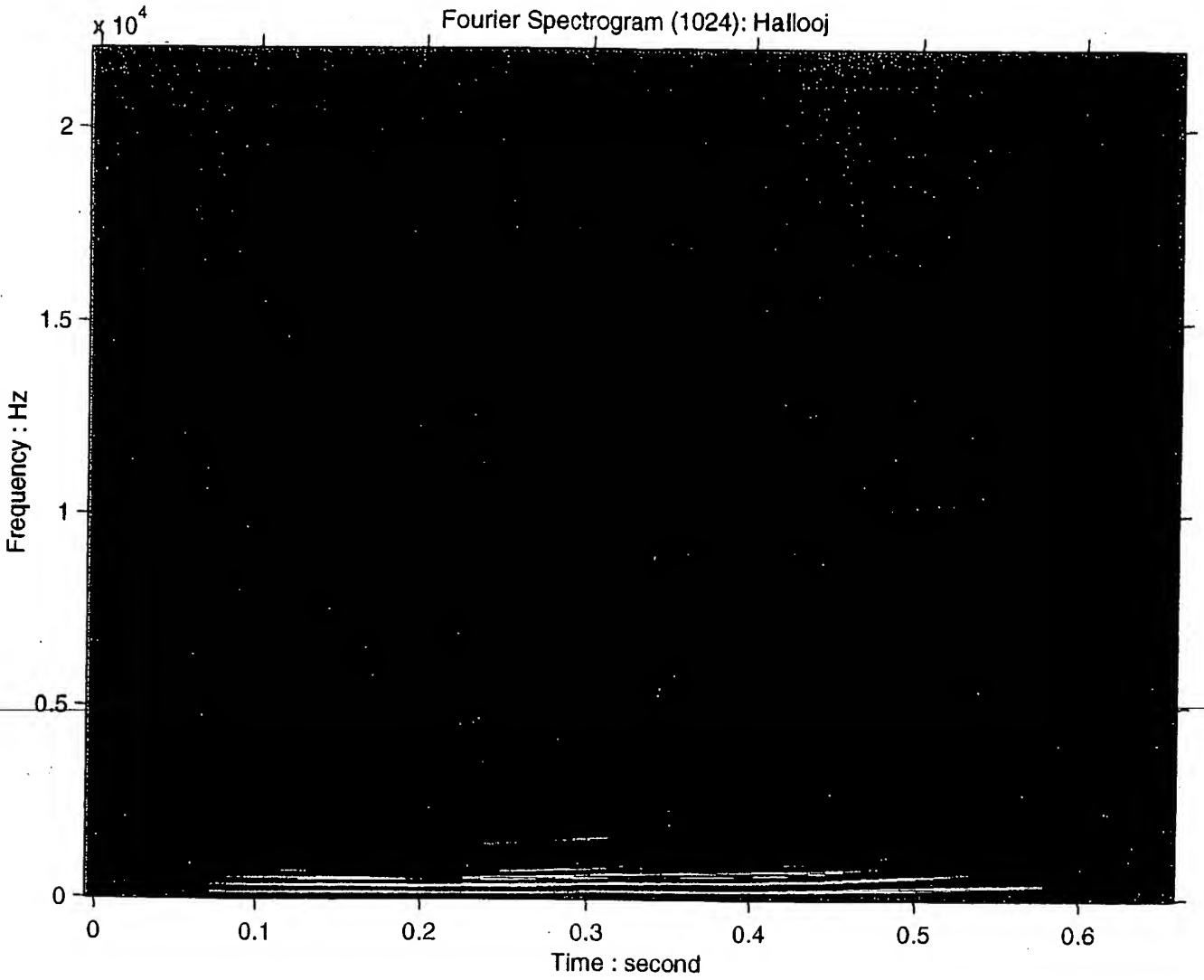

Fourier Spectrogram (1024): Hallooj
x 10^4
Frequency : Hz
2
1.5
1
0.5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 49(a)

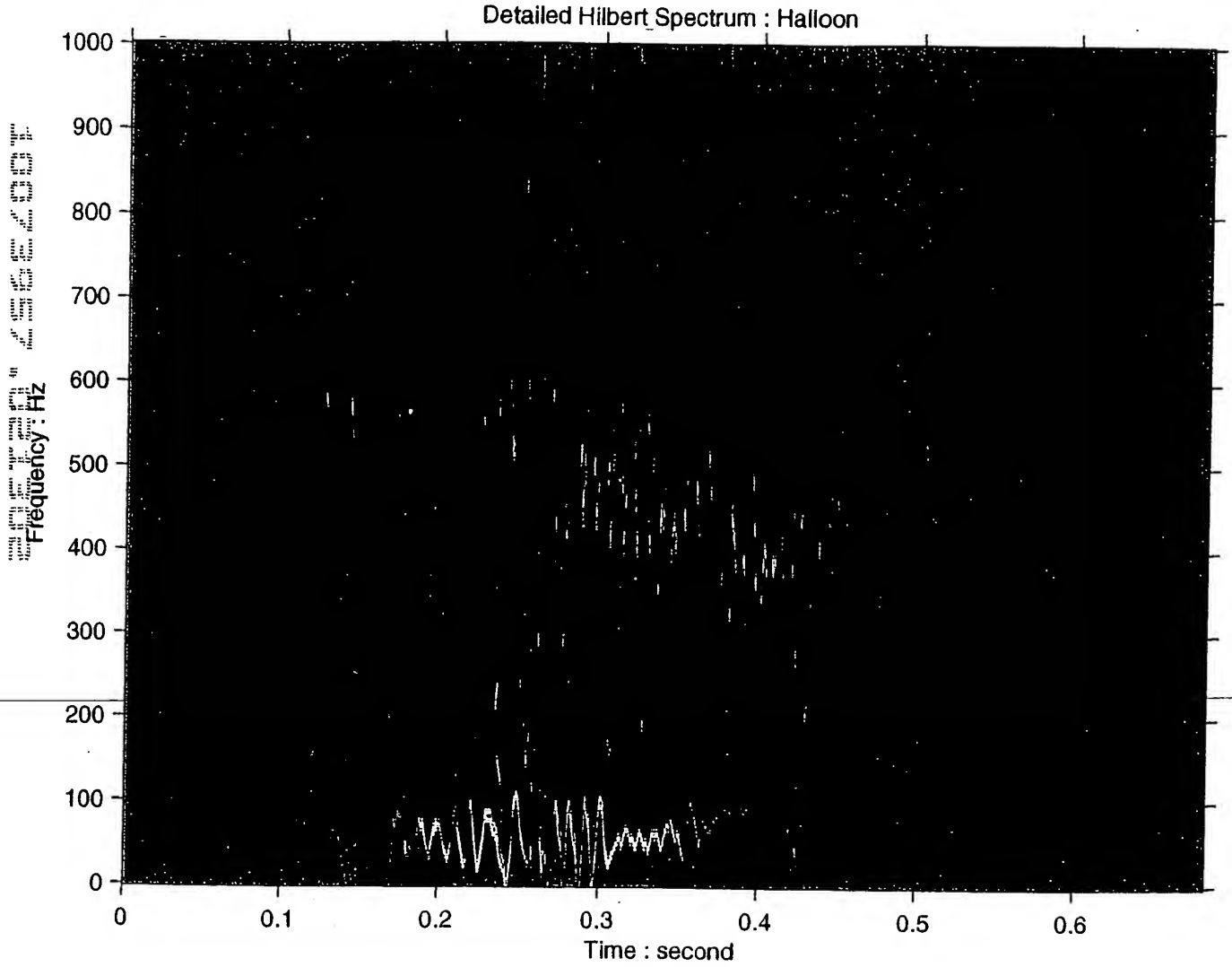

Detailed Hilbert Spectrum : Halloon
Frequency : Hz
1000
900
800
700
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 49(b)

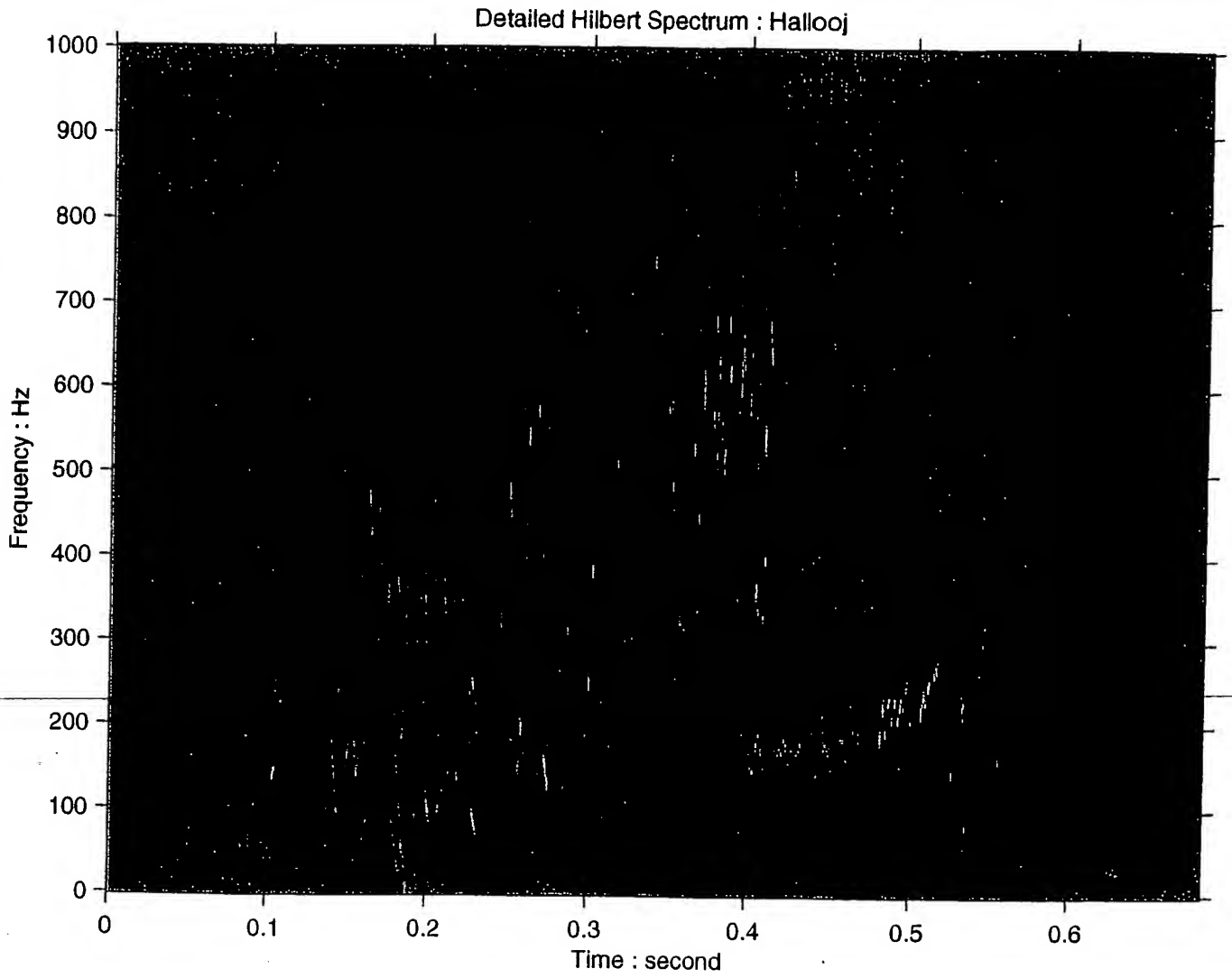

Detailed Hilbert Spectrum : Hallooj
Frequency : Hz
1000
900
800
700
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 50

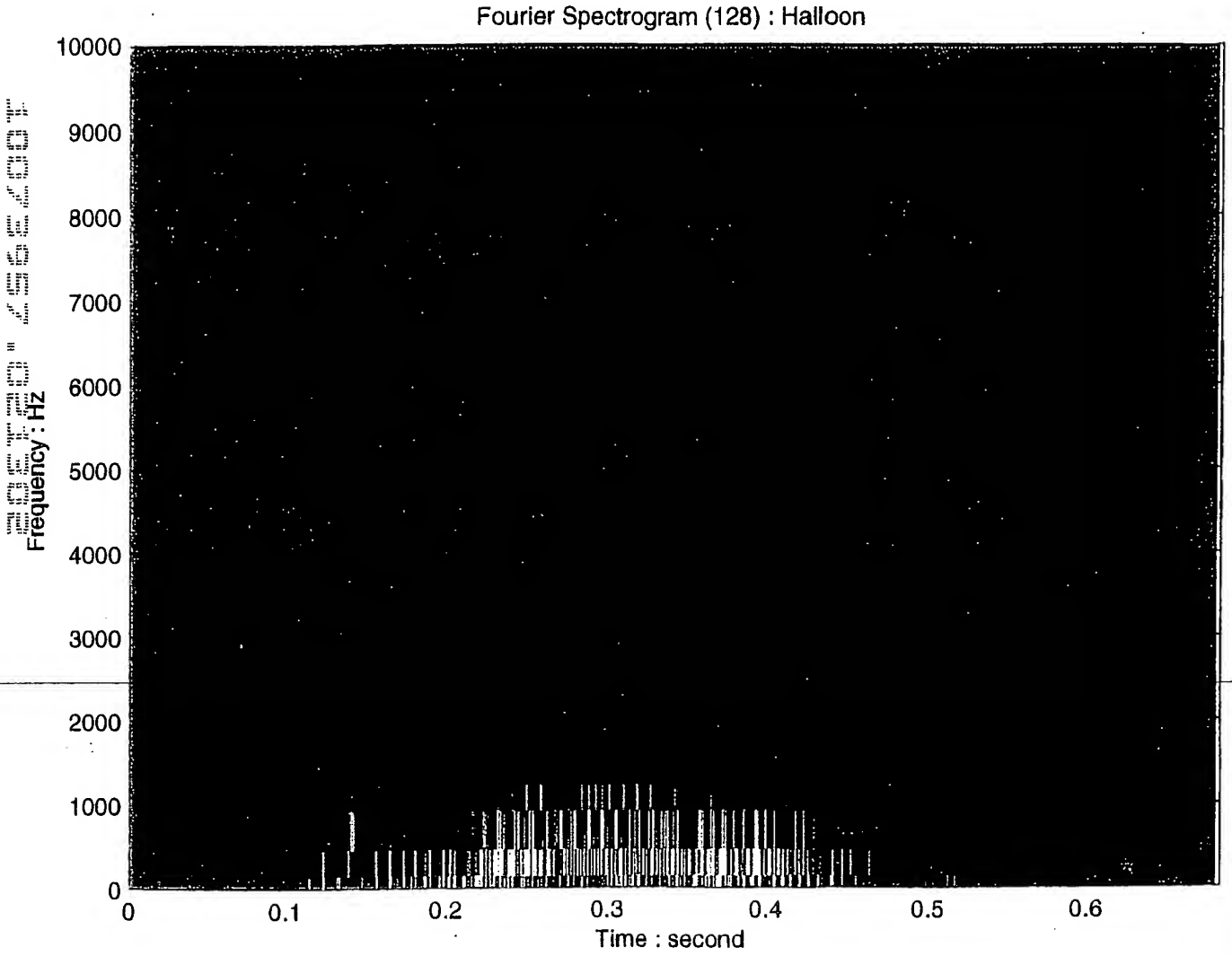

Fourier Spectrogram (128) : Halloon
Frequency : Hz
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 51(a)

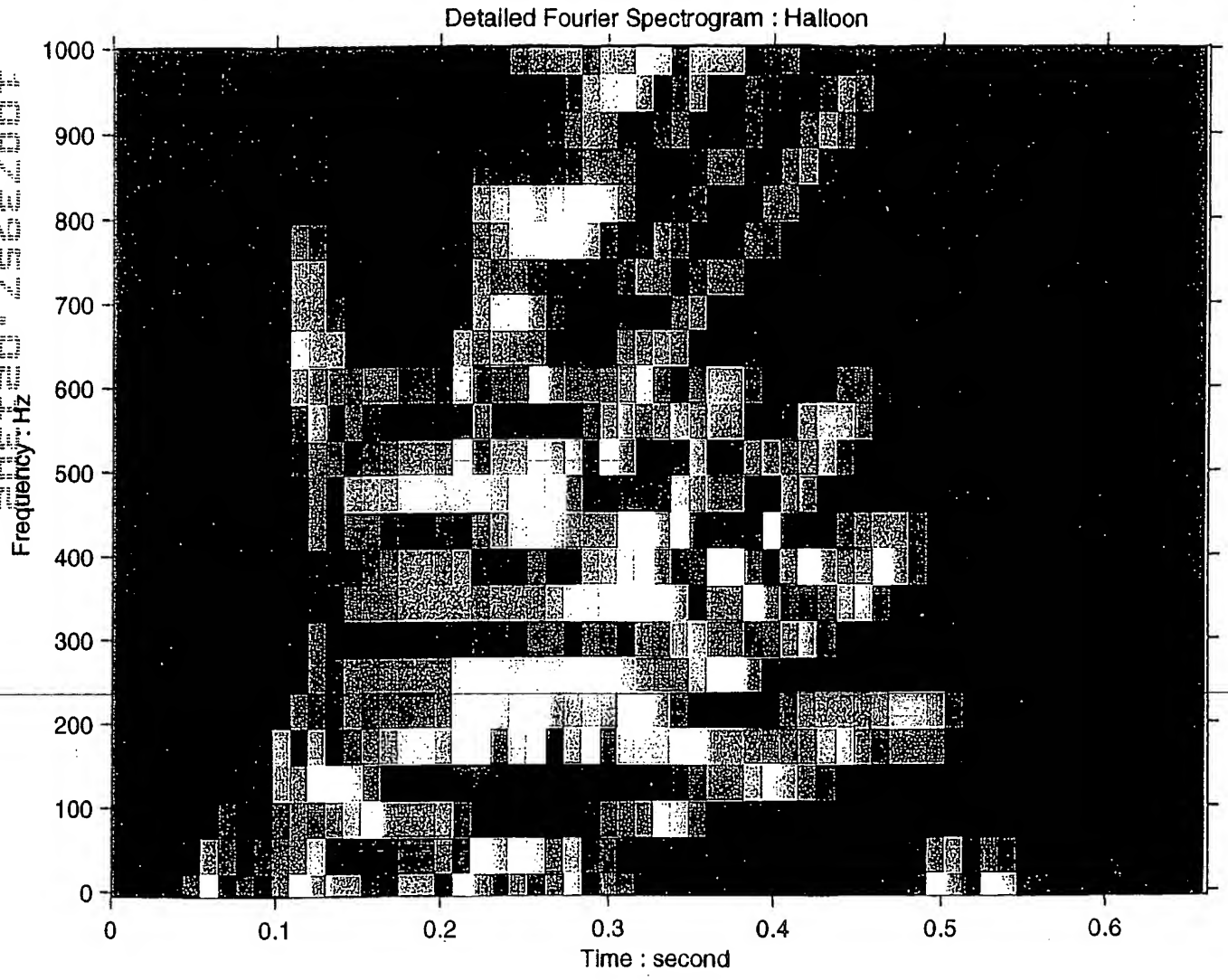

Detailed Fourier Spectrogram : Halloon
Frequency : Hz
1000
900
800
700
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 51(b)

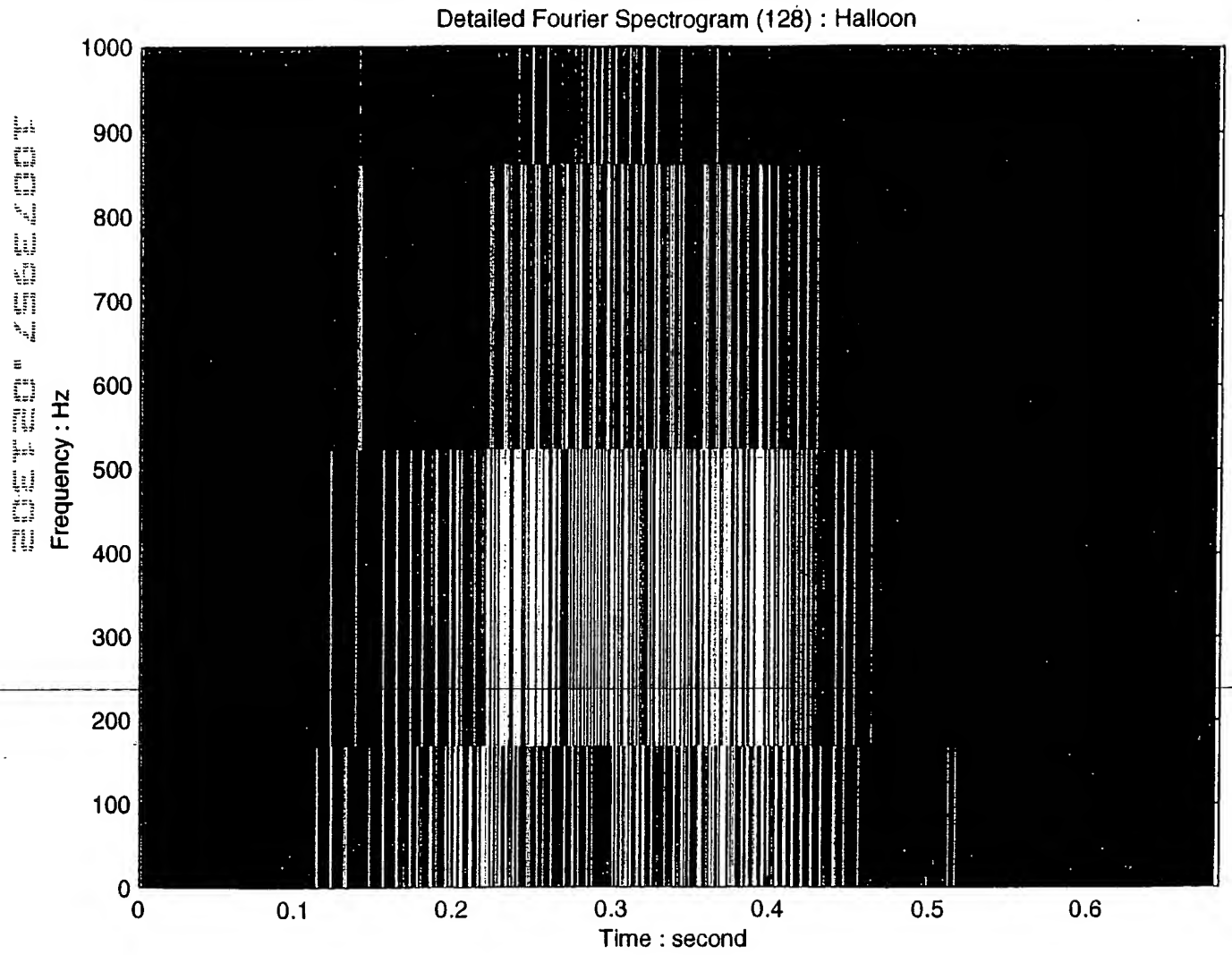

Detailed Fourier Spectrogram (128) : Halloon
Frequency : Hz
1000
900
800
700
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 52(a)

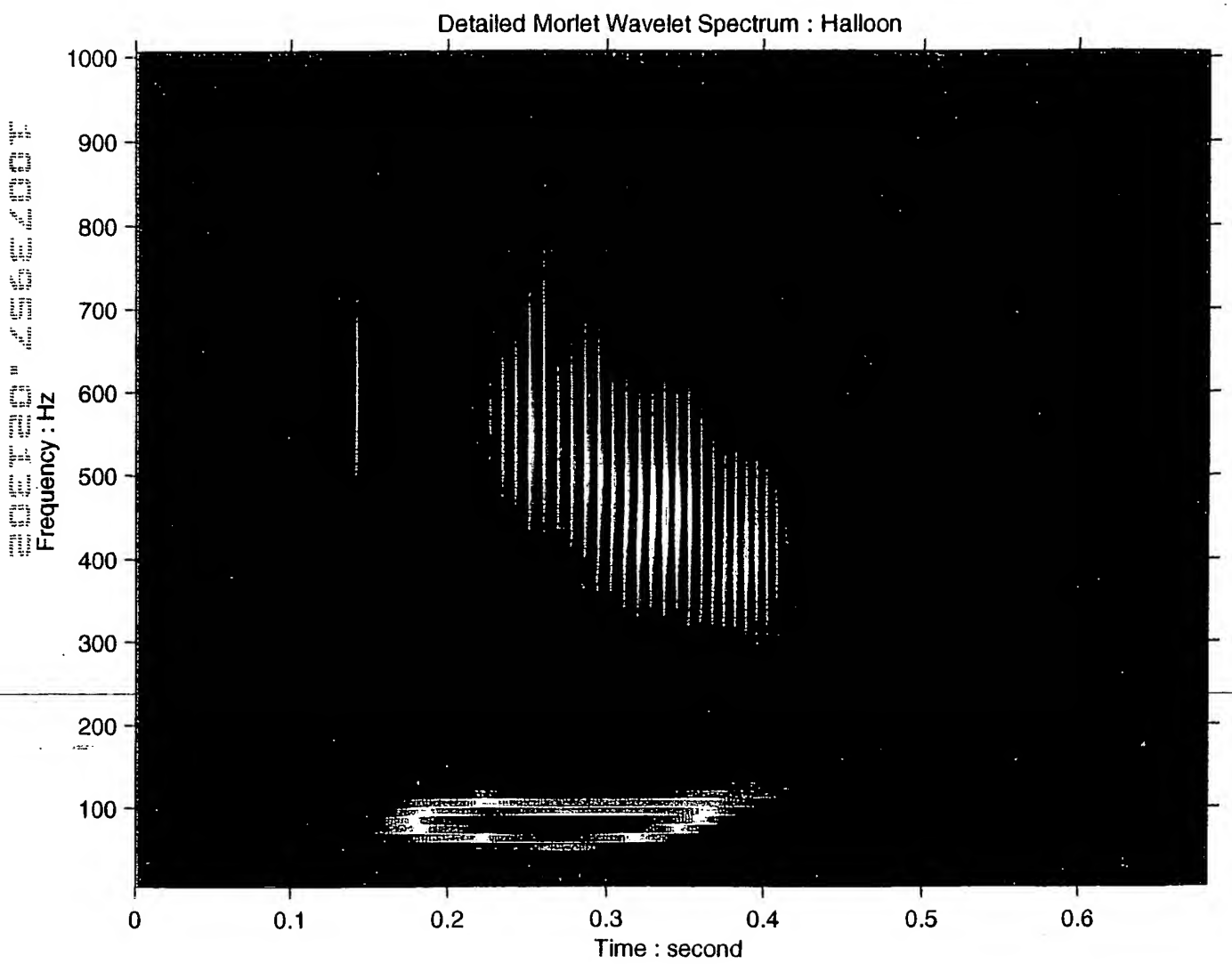

Detailed Morlet Wavelet Spectrum : Halloon
Frequency : Hz
1000
900
800
700
600
500
400
300
200
100
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 52(b)

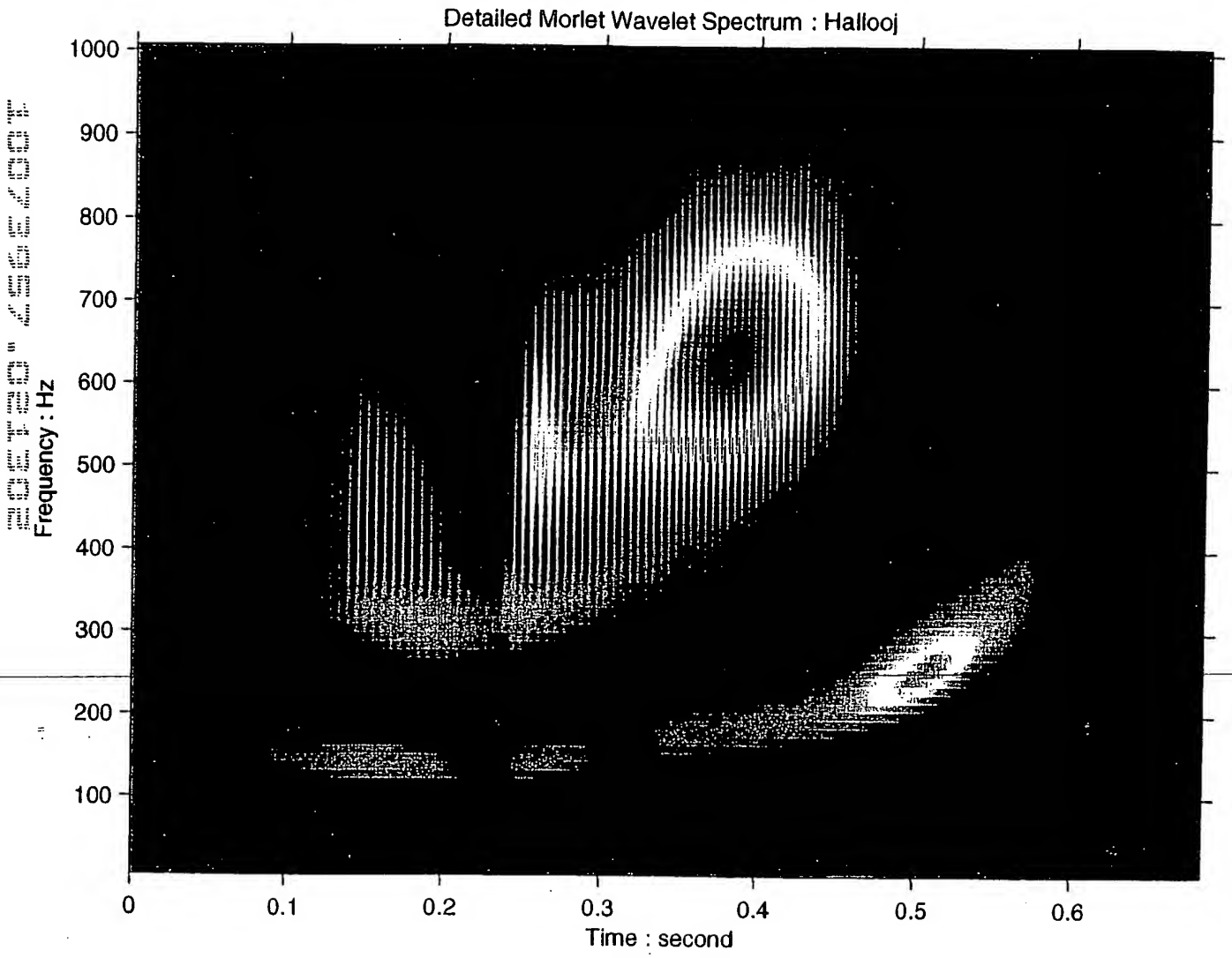

Detailed Morlet Wavelet Spectrum : Hallooj
Frequency : Hz
1000
900
800
700
600
500
400
300
200
100
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 53(a)

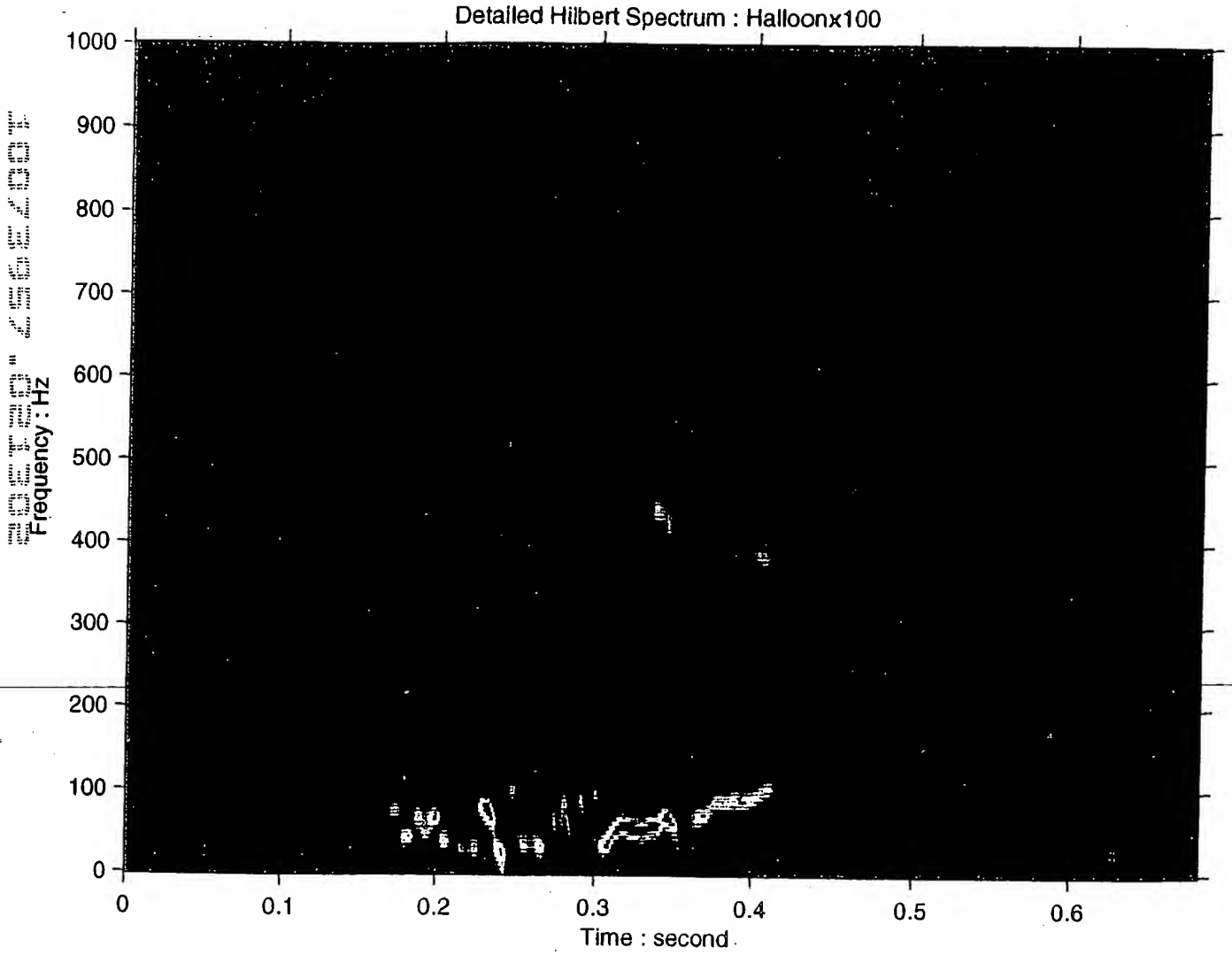

Detailed Hilbert Spectrum : Halloonx100
Frequency : Hz
1000
900
800
700
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 53(b)

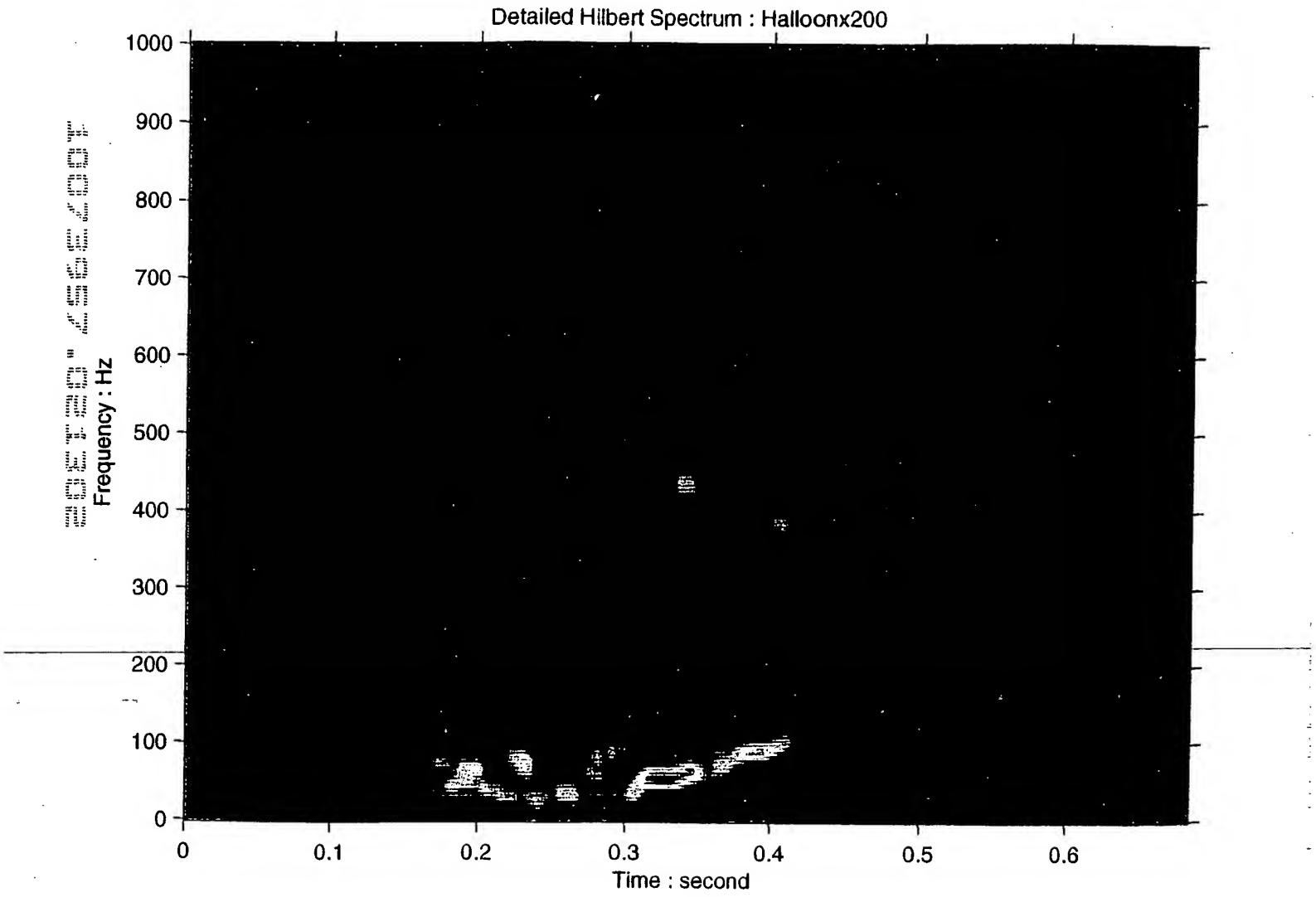

Detailed Hilbert Spectrum : Halloonx200
Frequency : Hz
1000
900
800
700
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 54(a)

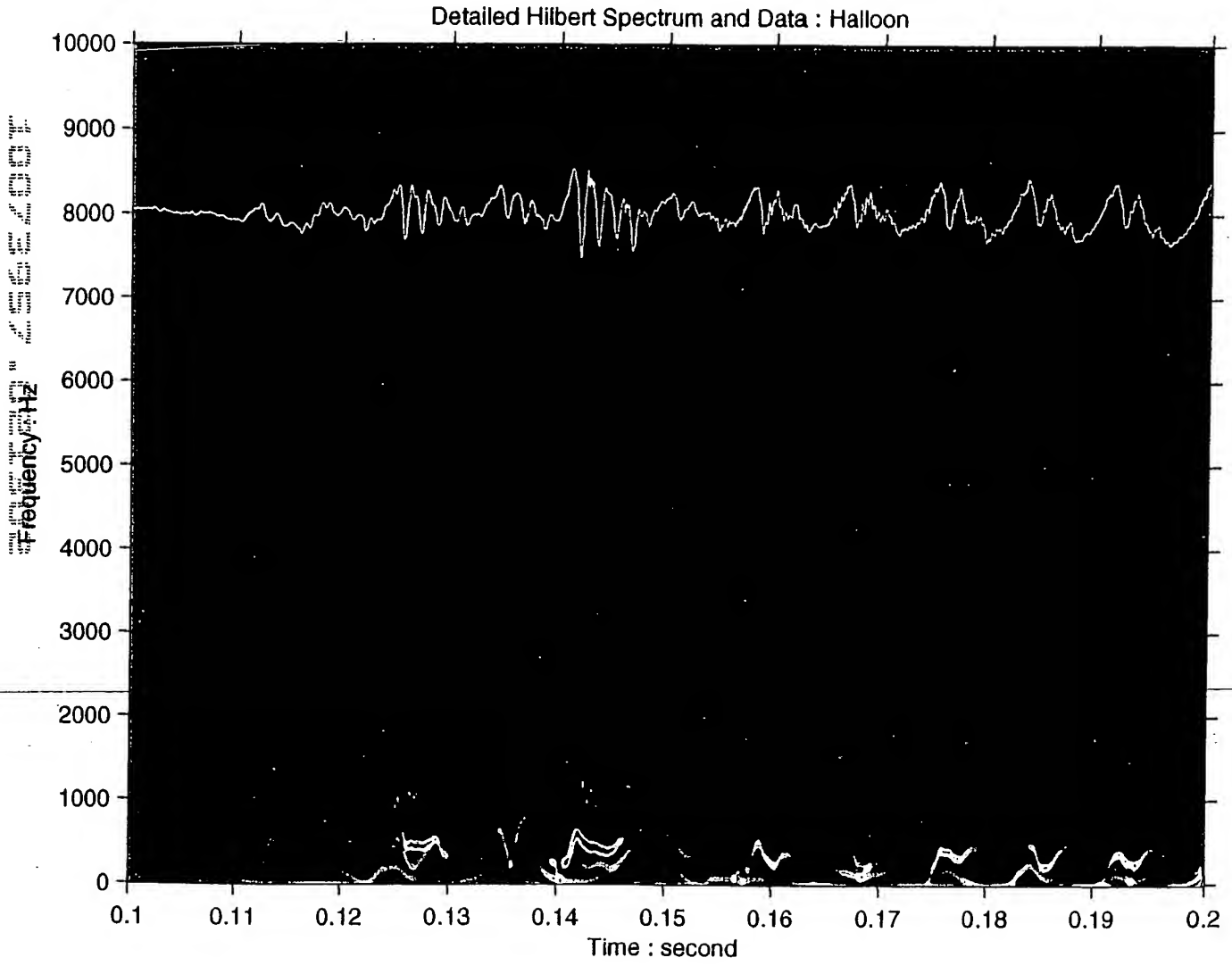

Detailed Hilbert Spectrum and Data : Halloon
Frequency : Hz
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.1
0.11
0.12
0.13
0.14
0.15
0.16
0.17
0.18
0.19
0.2
Time : second

FIG. 54(b)

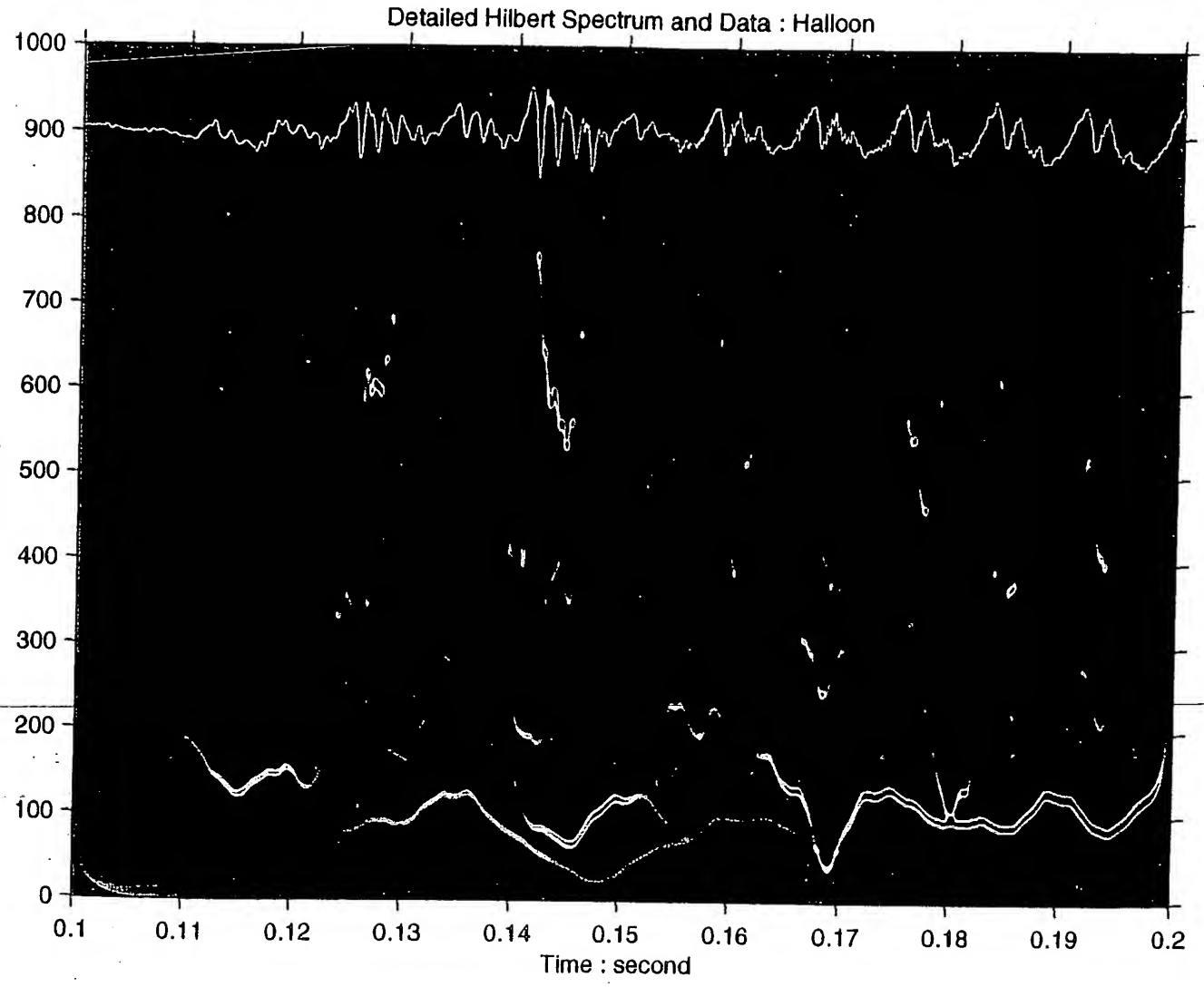

Detailed Hilbert Spectrum and Data : Halloon
Frequency : Hz
1000
900
800
700
600
500
400
300
200
100
0
0.1
0.11
0.12
0.13
0.14
0.15
0.16
0.17
0.18
0.19
0.2
Time : second

FIG. 55

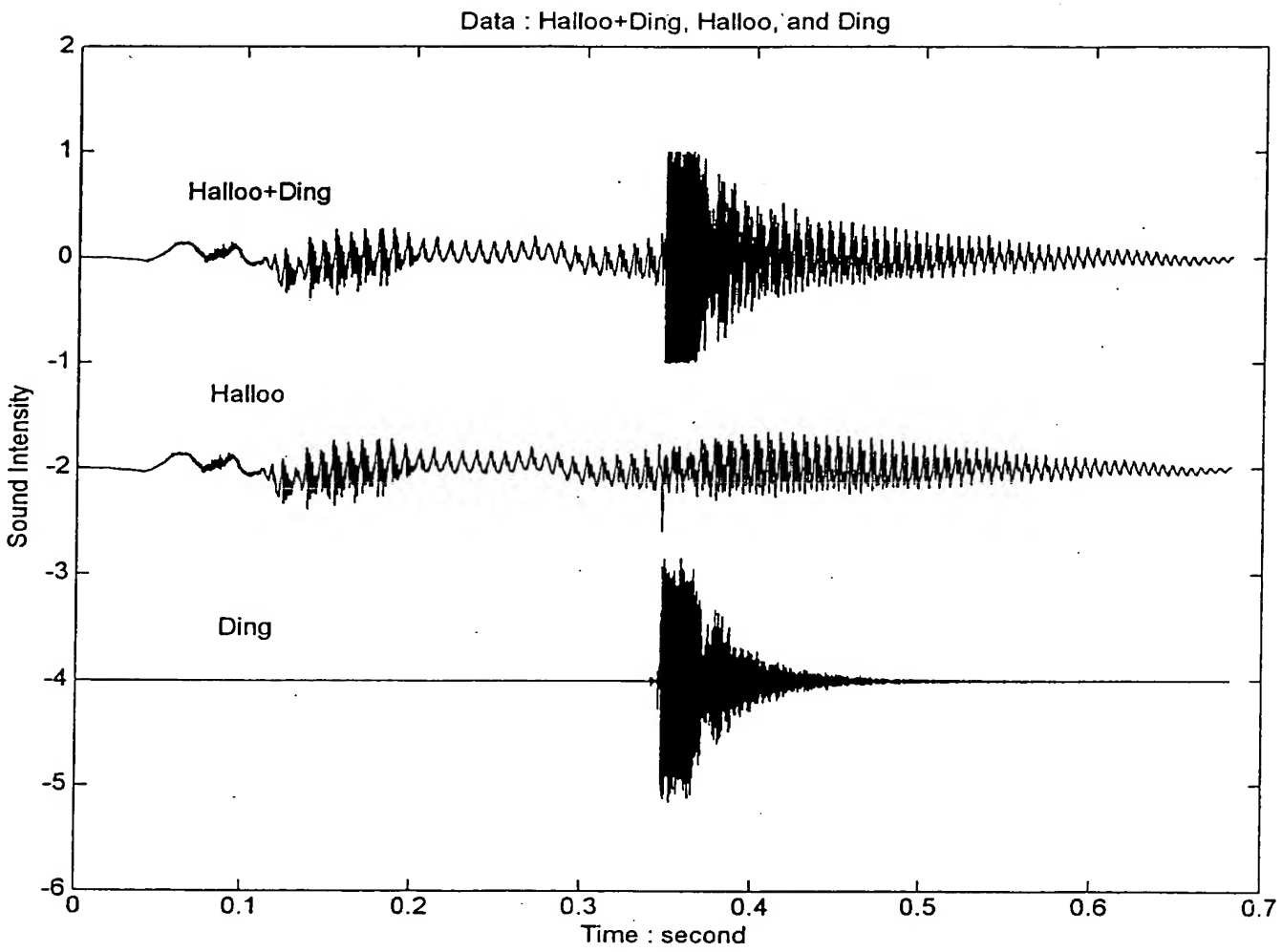

Data : Halloo+Ding, Halloo, and Ding
Halloo+Ding
Halloo
Ding
Sound Intensity
Time : second
2
1
0
-1
-2
-3
-4
-5
-6
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

FIG. 56(a)

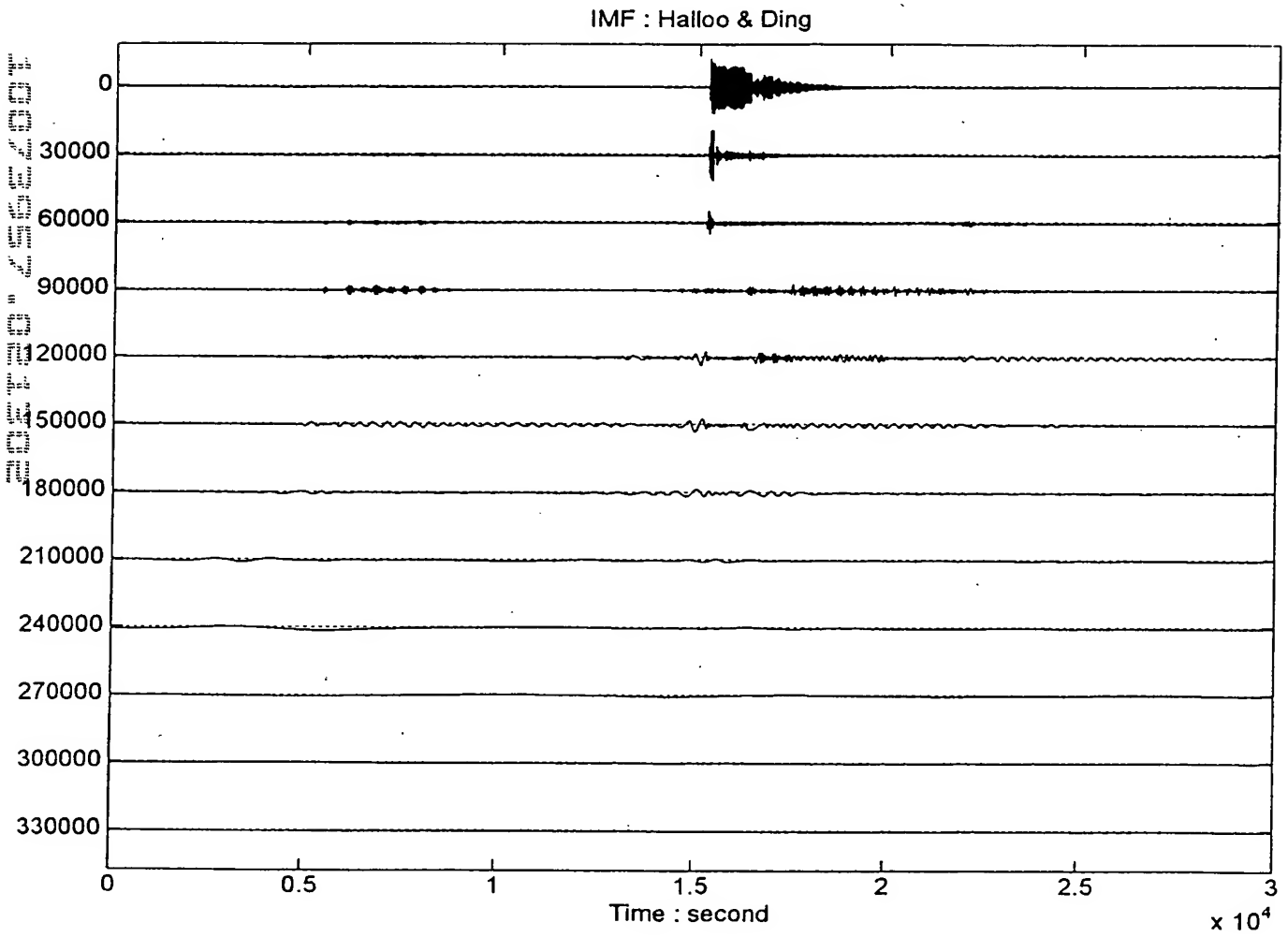

IMF : Halloo & Ding
0
30000
60000
90000
120000
150000
180000
210000
240000
270000
300000
330000
0
0.5
1
1.5
2
2.5
3
Time : second
x 10^4

FIG. 56(b)

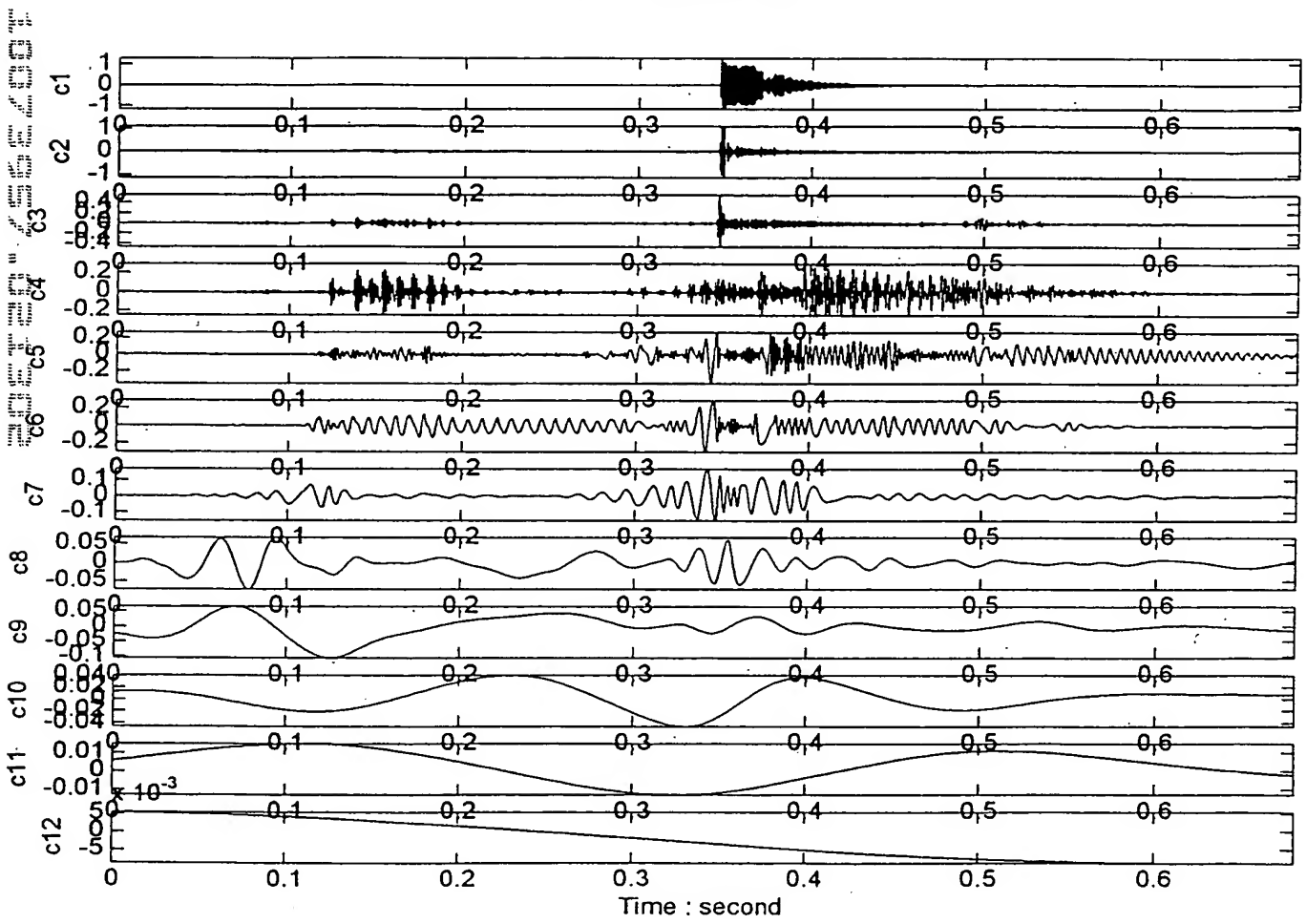

IMF : Halloo & Ding
c1
c2
c3
c4
c5
c6
c7
c8
c9
c10
c11
c12
× 10^-3
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 57(a)

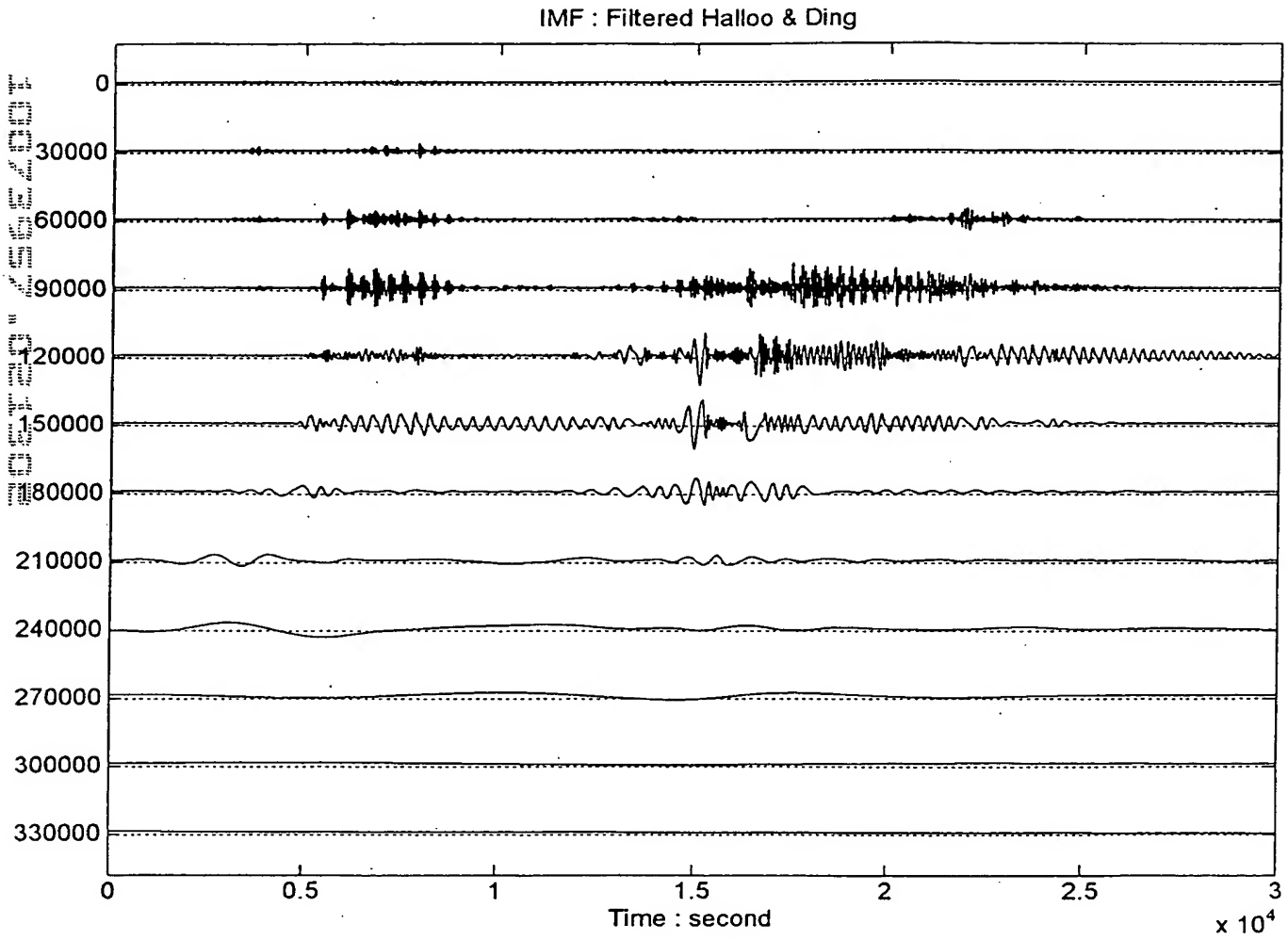

IMF : Filtered Halloo & Ding
0
30000
60000
90000
120000
150000
180000
210000
240000
270000
300000
330000
0
0.5
1
1.5
2
2.5
3
Time : second
x 10^4

FIG. 57(b)

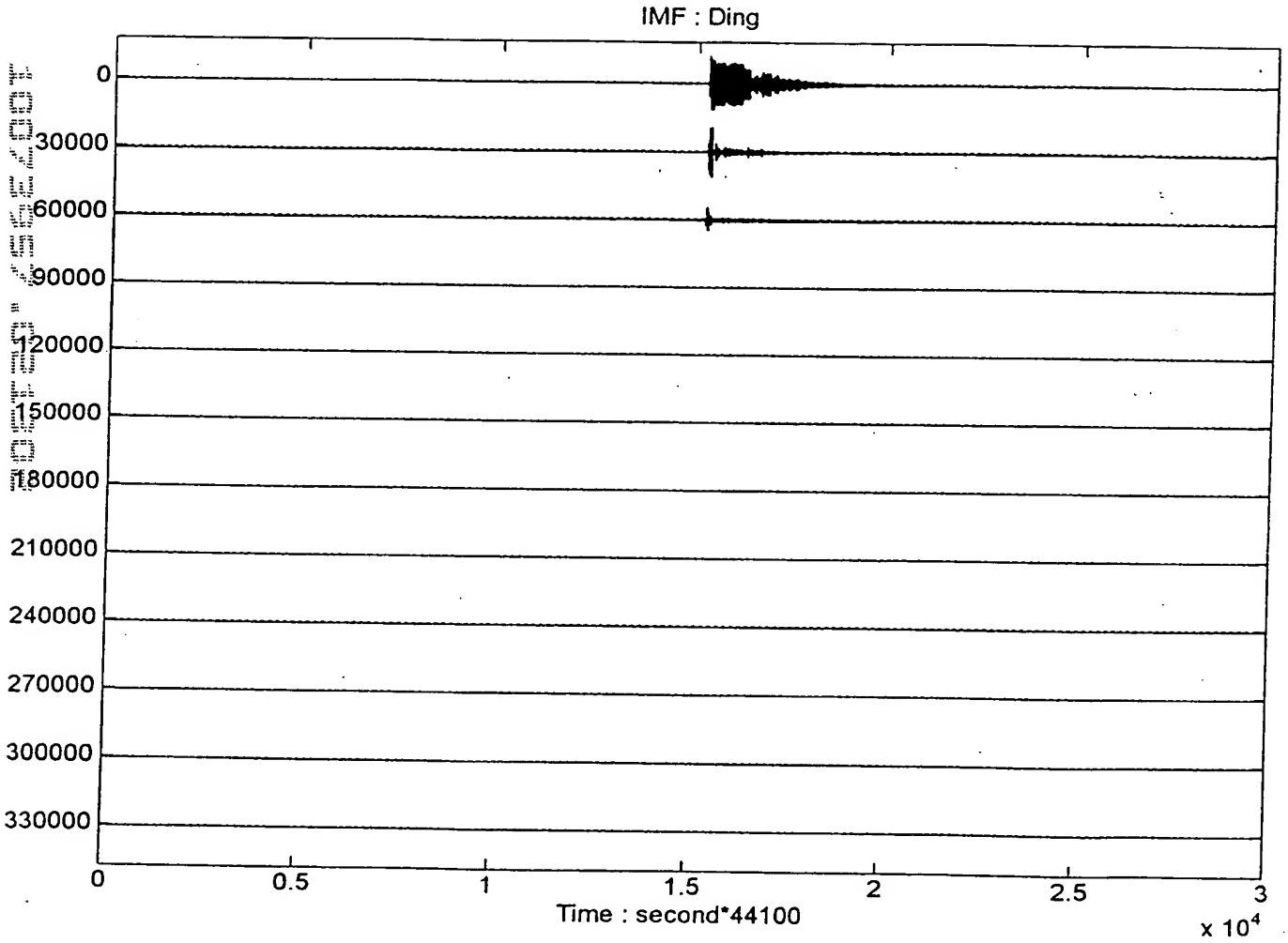

IMF : Ding
0
30000
60000
90000
120000
150000
180000
210000
240000
270000
300000
330000
0
0.5
1
1.5
2
2.5
3
Time : second*44100
x 10^4

FIG. 58(a)

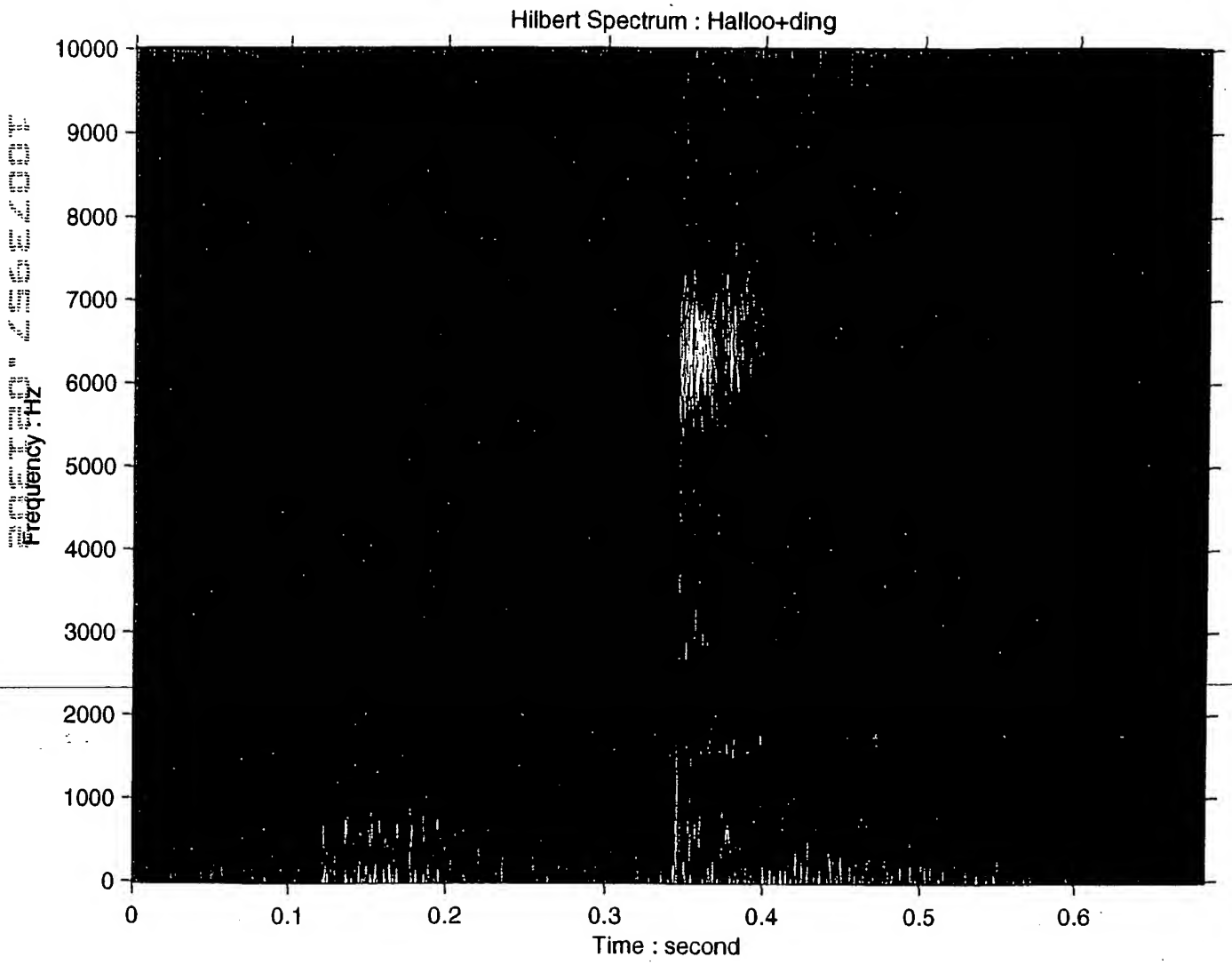

Hilbert Spectrum : Halloo+ding
Frequency : Hz
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 58(b)

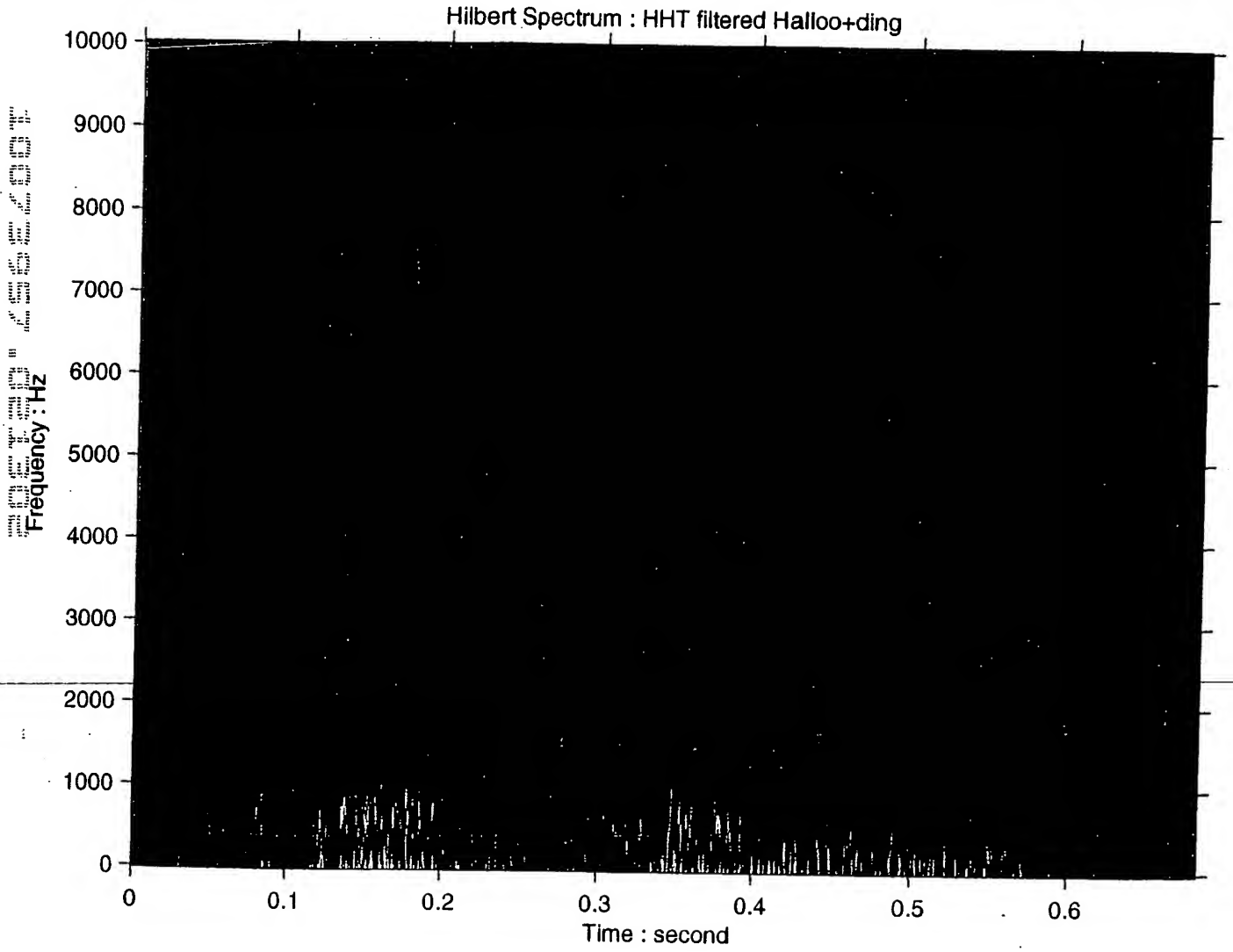

Hilbert Spectrum : HHT filtered Halloo+ding
Frequency : Hz
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Time : second

FIG. 59(a)

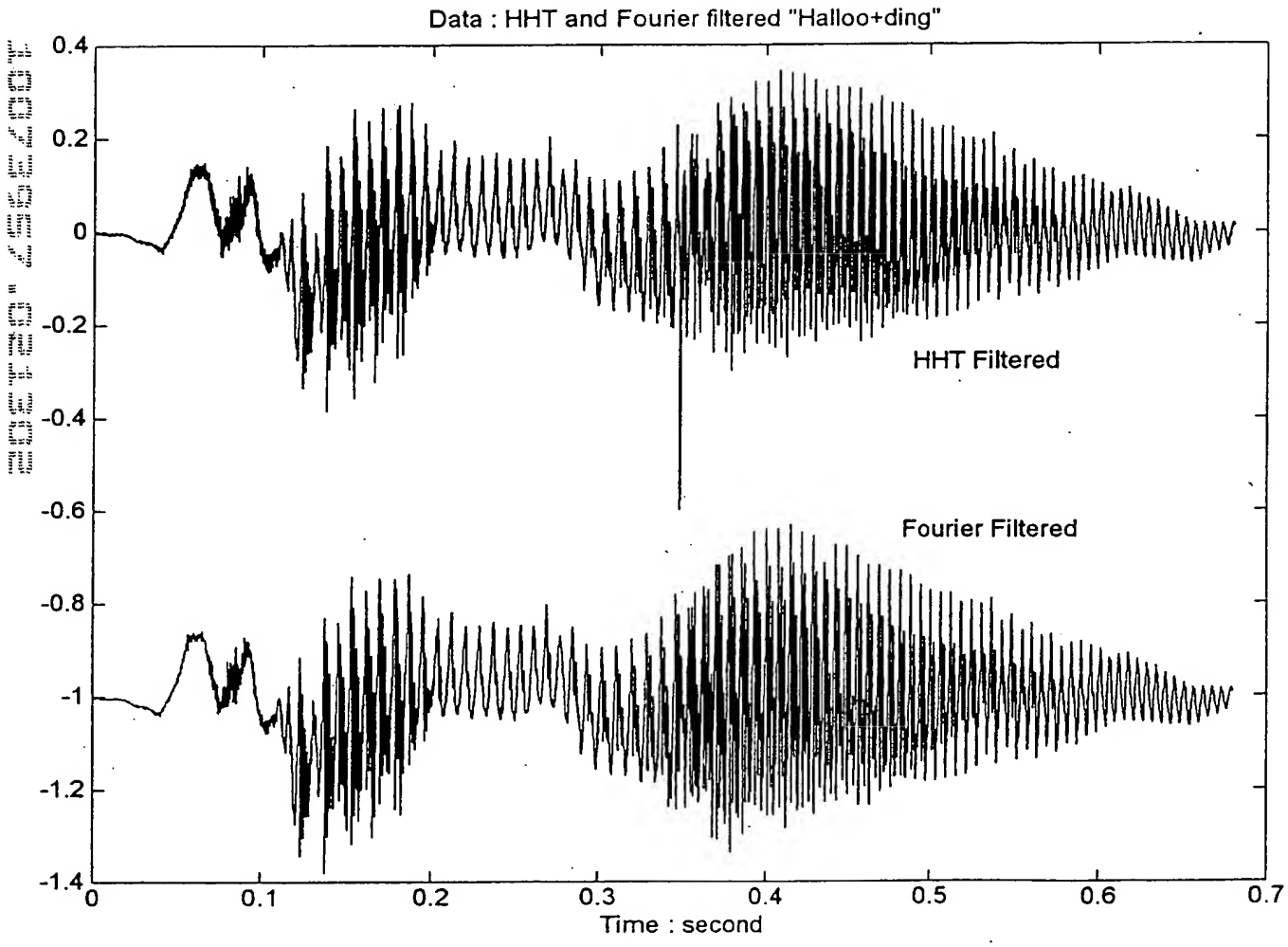

Data : HHT and Fourier filtered "Halloo+ding"
Amplitude
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
HHT Filtered
Fourier Filtered
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Time : second

FIG. 59(b)

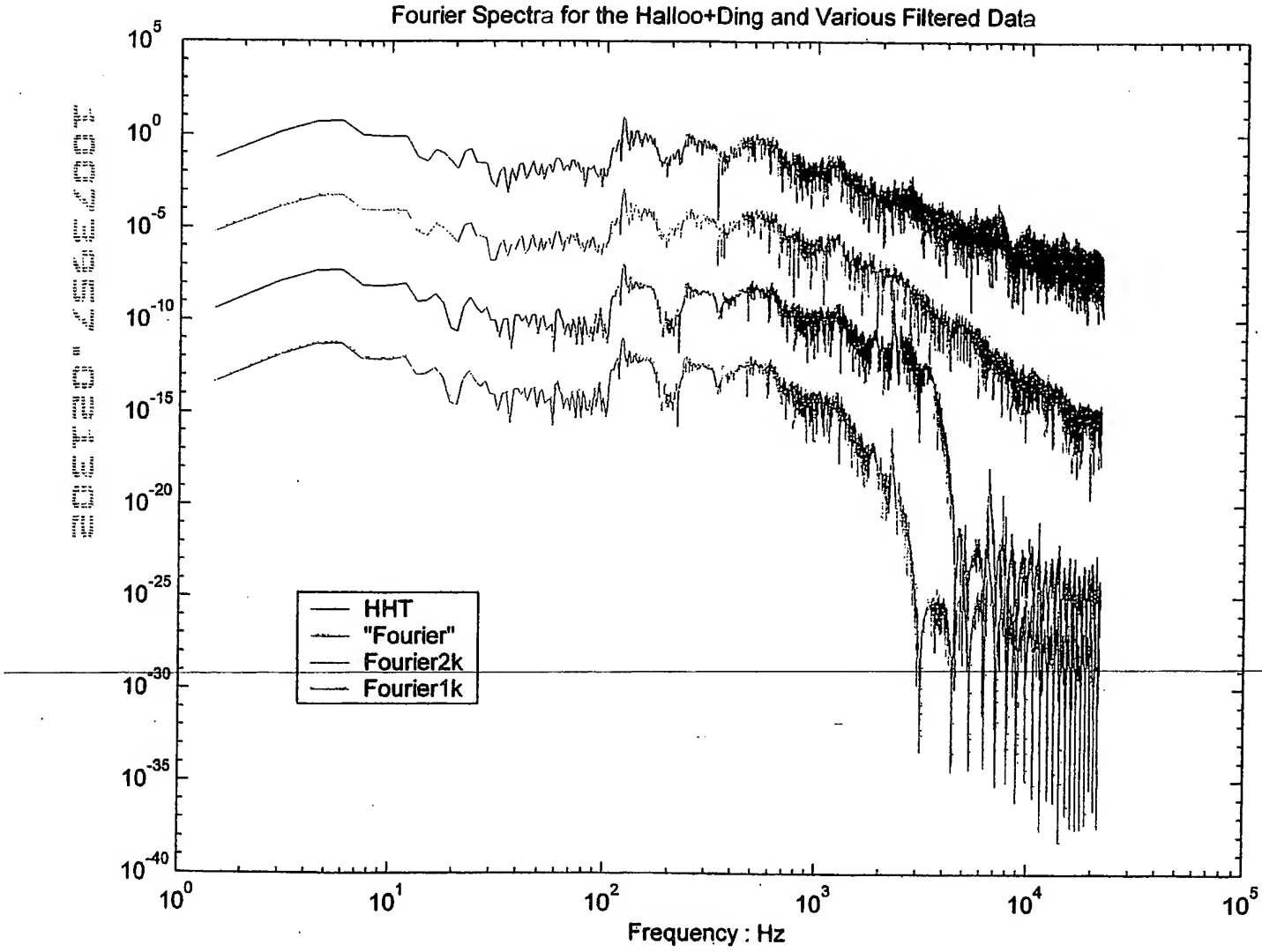

Fourier Spectra for the Halloo+Ding and Various Filtered Data
HHT
"Fourier"
Fourier2k
Fourier1k
Frequency : Hz

FIG. 60(a)

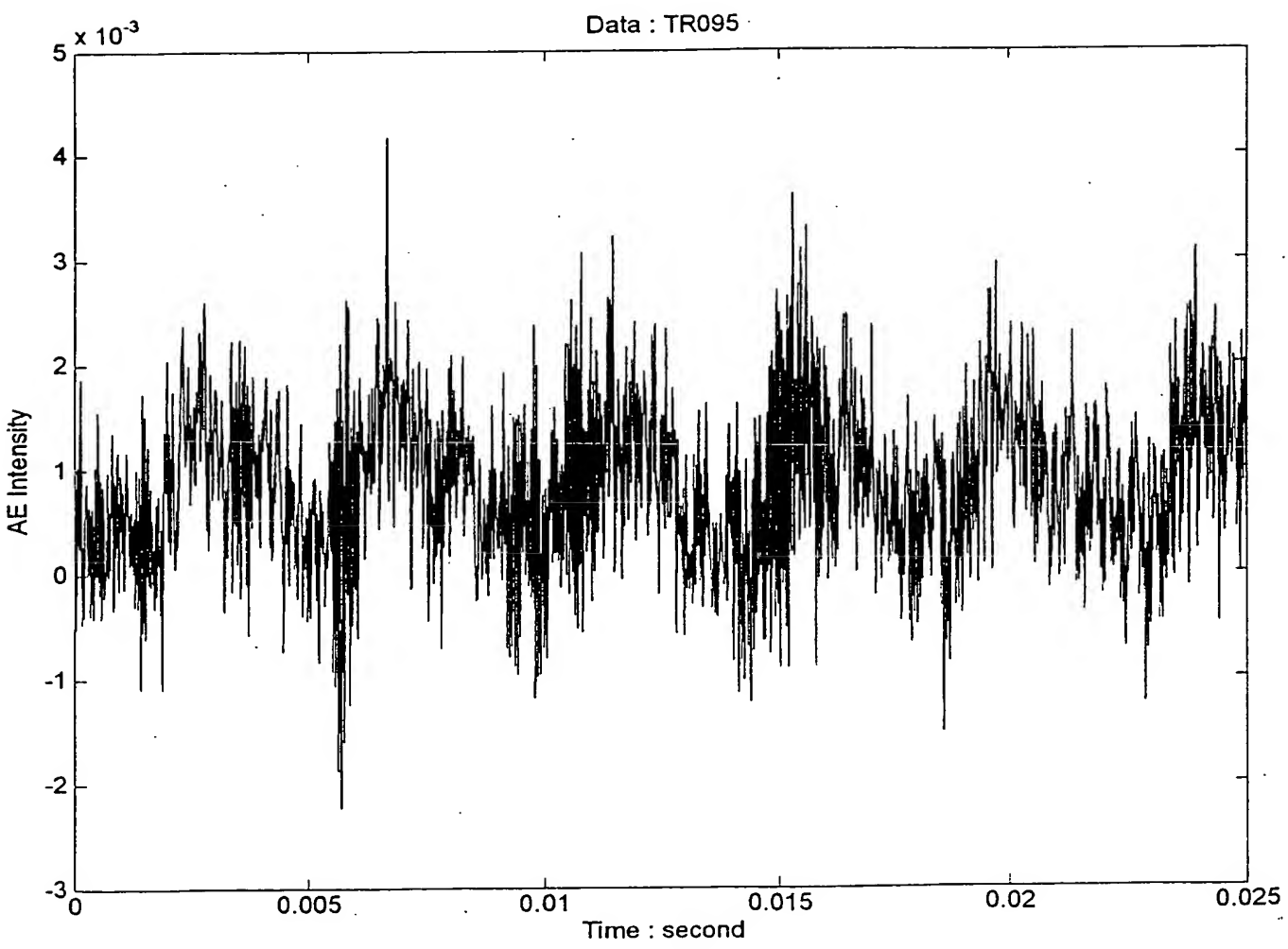

Data : TR095
x 10^-3
5
4
3
2
1
0
-1
-2
-3
AE Intensity
0
0.005
0.01
0.015
0.02
0.025
Time : second

FIG. 60(b)

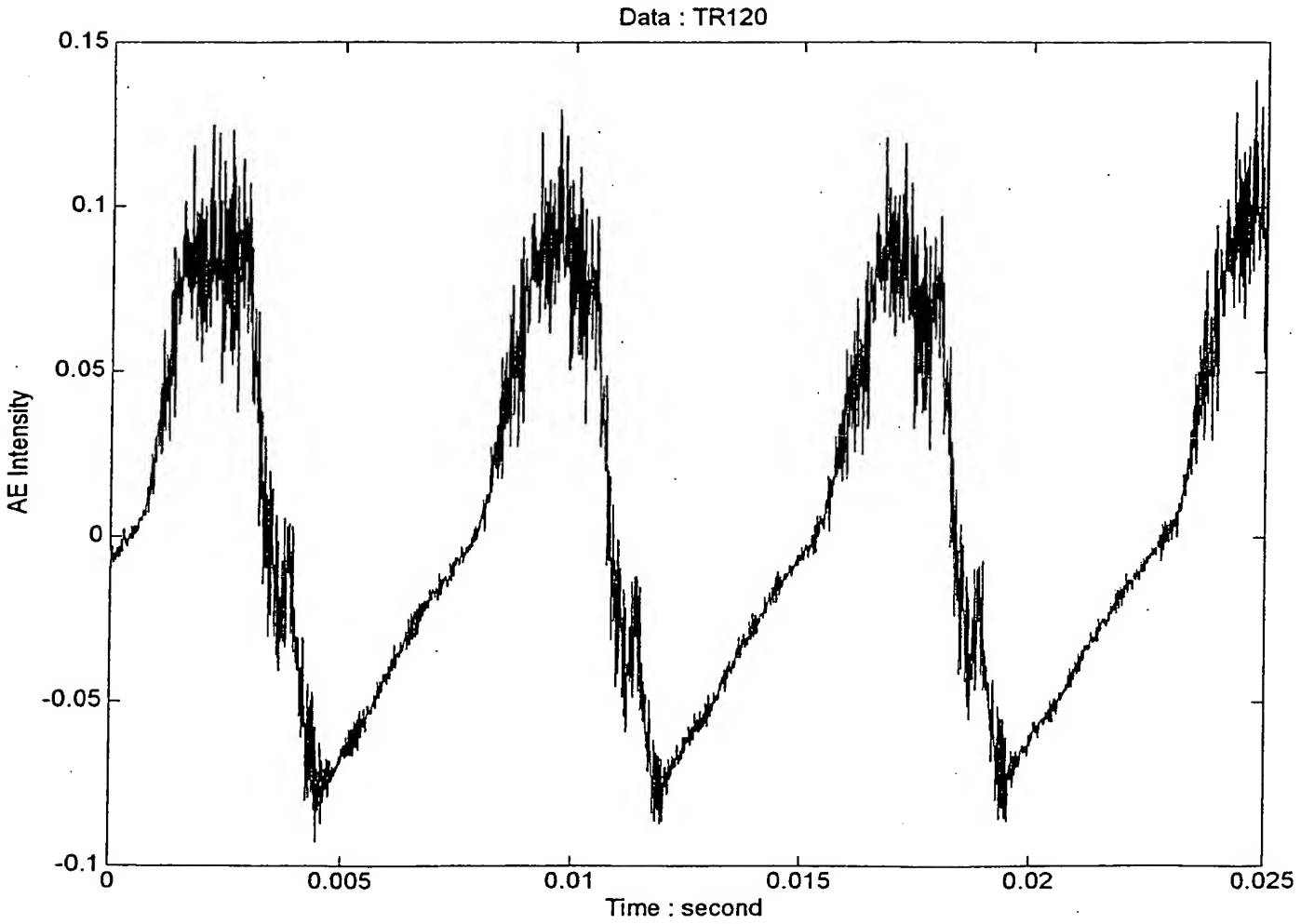

Data : TR120
AE Intensity
Time : second
0.15
0.1
0.05
0
-0.05
-0.1
0
0.005
0.01
0.015
0.02
0.025

FIG. 60(c)

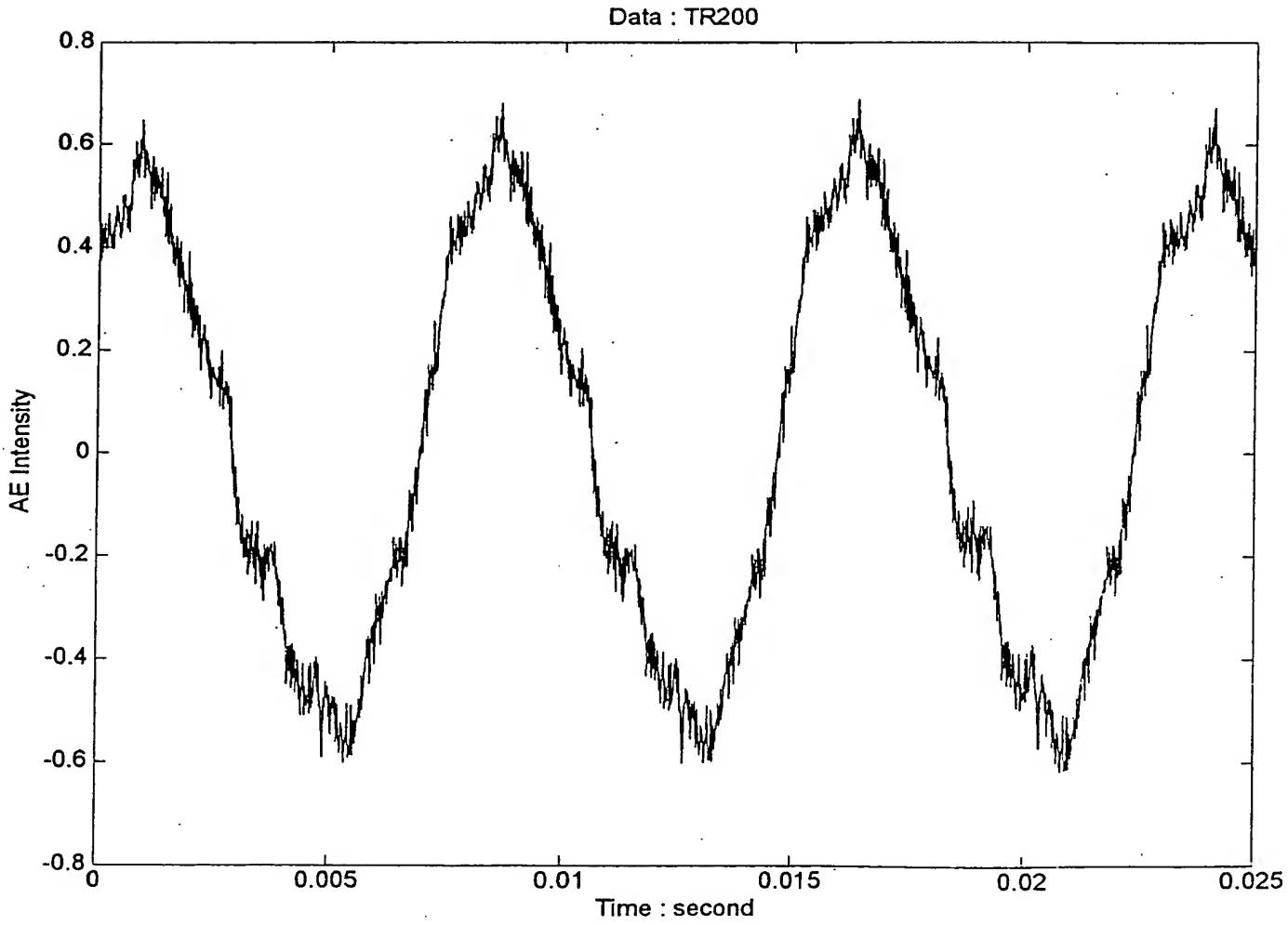

Data : TR200
AE Intensity
Time : second
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
0.005
0.01
0.015
0.02
0.025

FIG. 61(a)

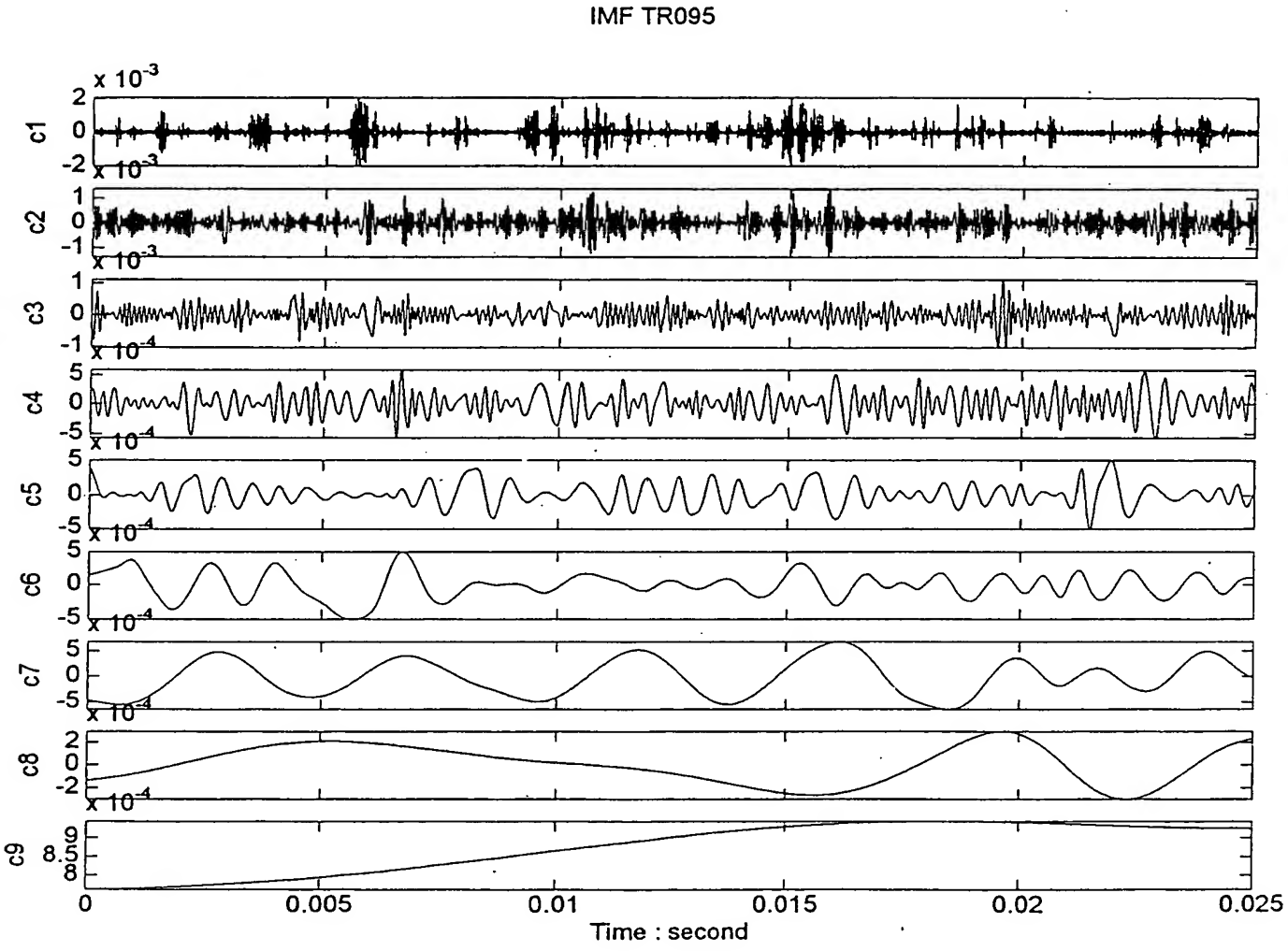

IMF TR095
c1
c2
c3
c4
c5
c6
c7
c8
c9
x 10^-3
x 10^-4
0
0.005
0.01
0.015
0.02
0.025
Time : second

FIG. 61(b)

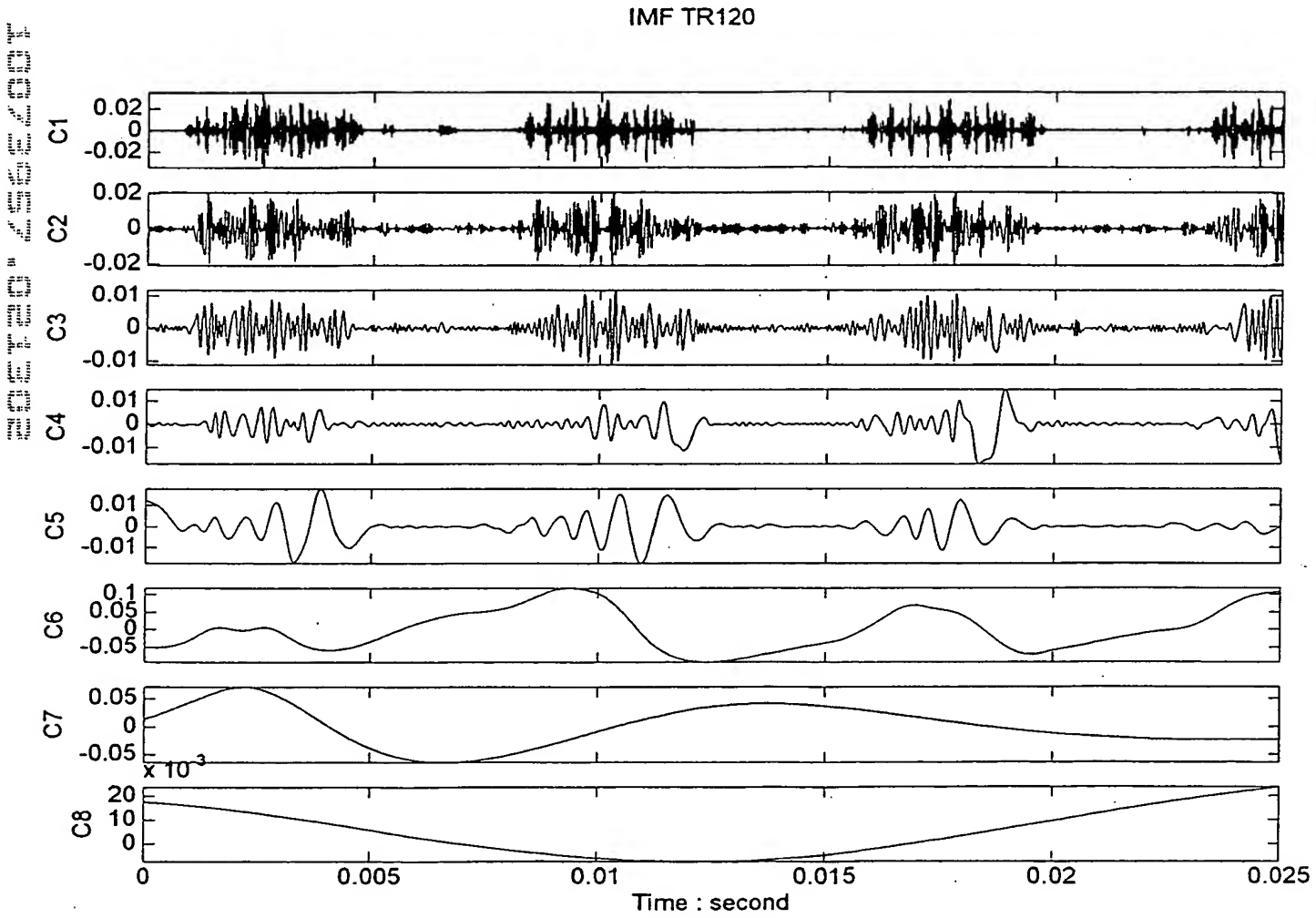


FIG. 61(c)

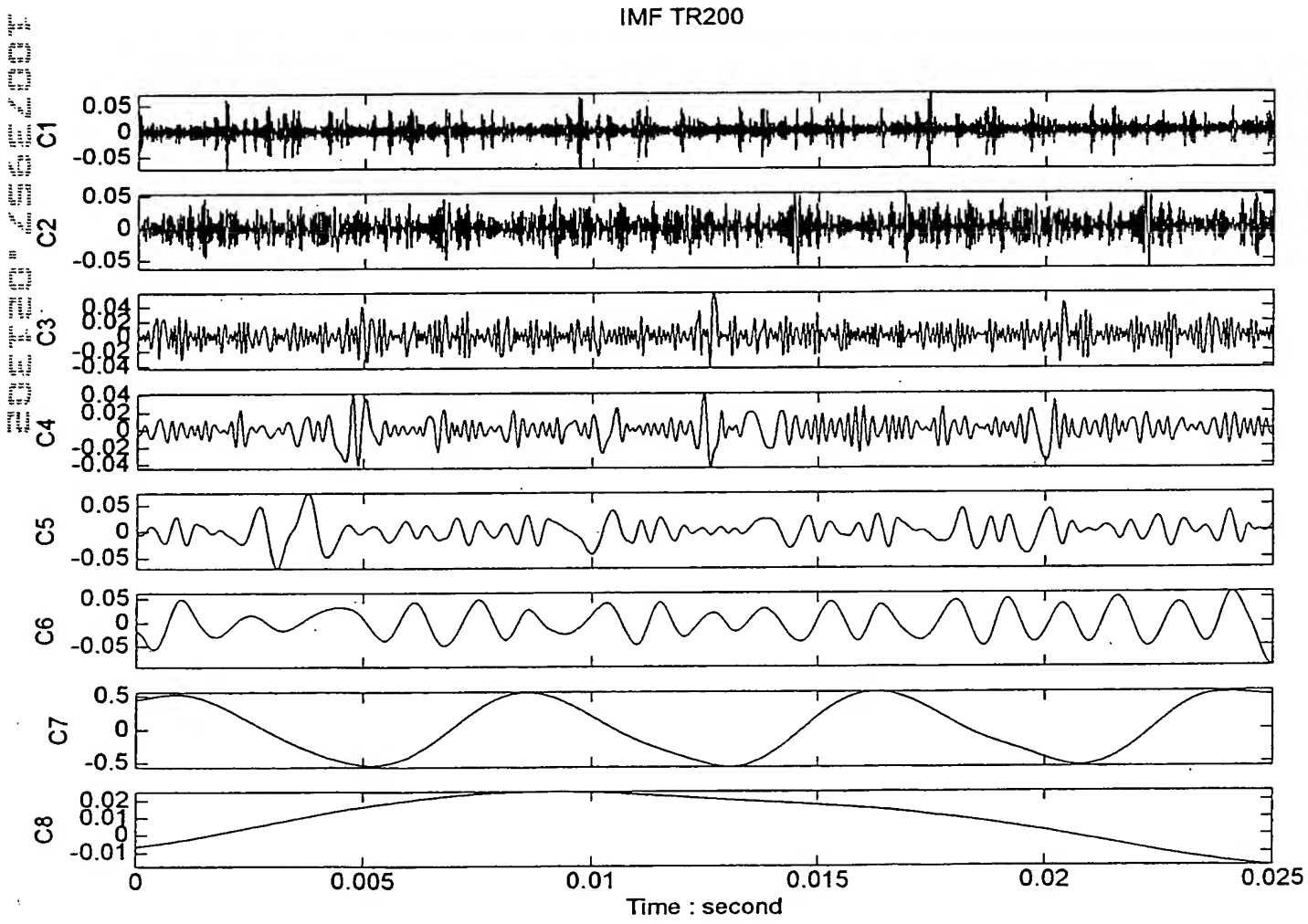

IMF TR200
C1
C2
C3
C4
C5
C6
C7
C8
0.05
0
-0.05
0.04
0.02
-0.02
-0.04
0.5
-0.5
0.01
-0.01
0
0.005
0.015
0.02
0.025
Time : second

FIG. 62(a)

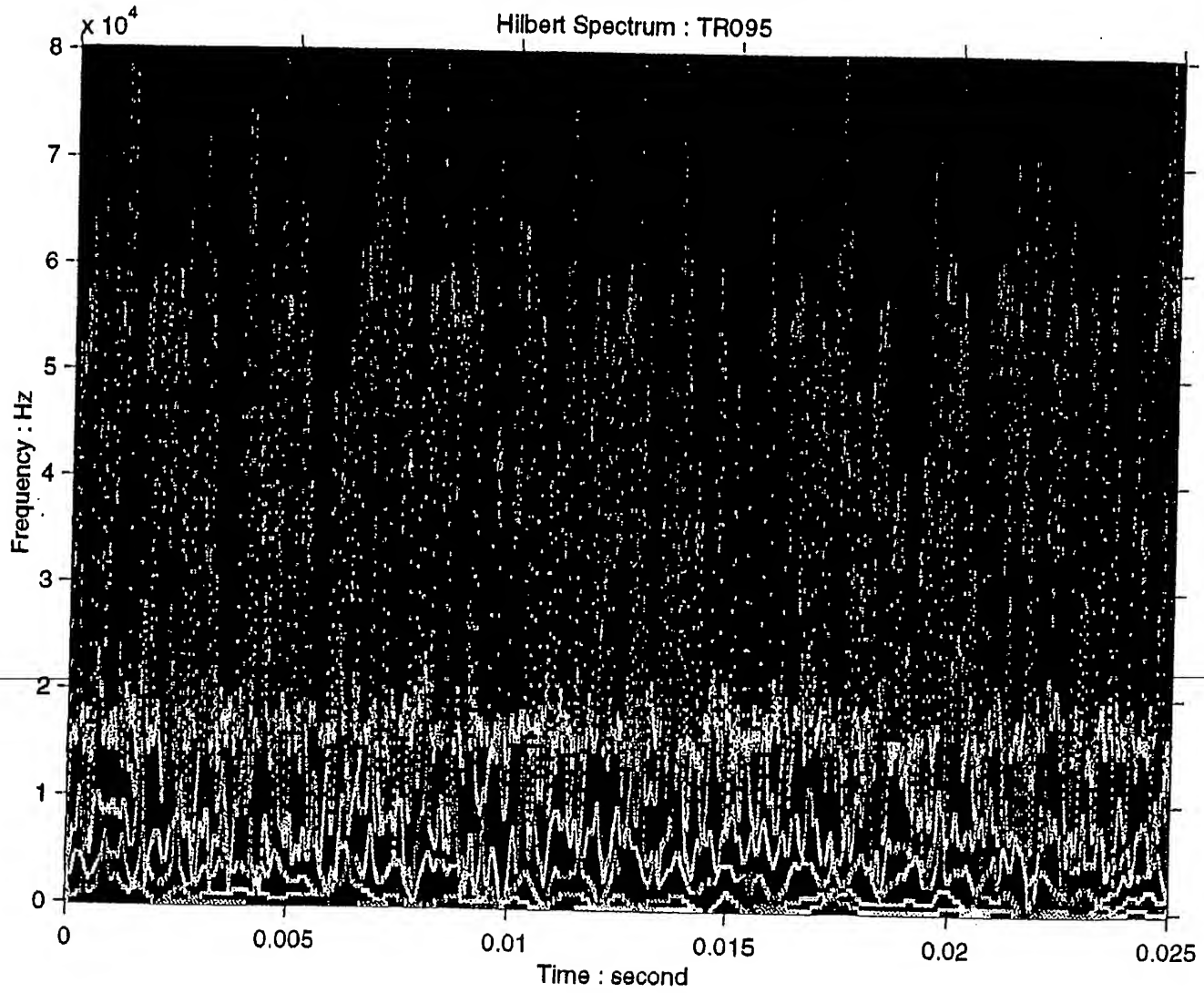

Hilbert Spectrum : TR095
x 10^4
Frequency : Hz
Time : second
0
1
2
3
4
5
6
7
8
0
0.005
0.01
0.015
0.02
0.025

FIG. 62(b)

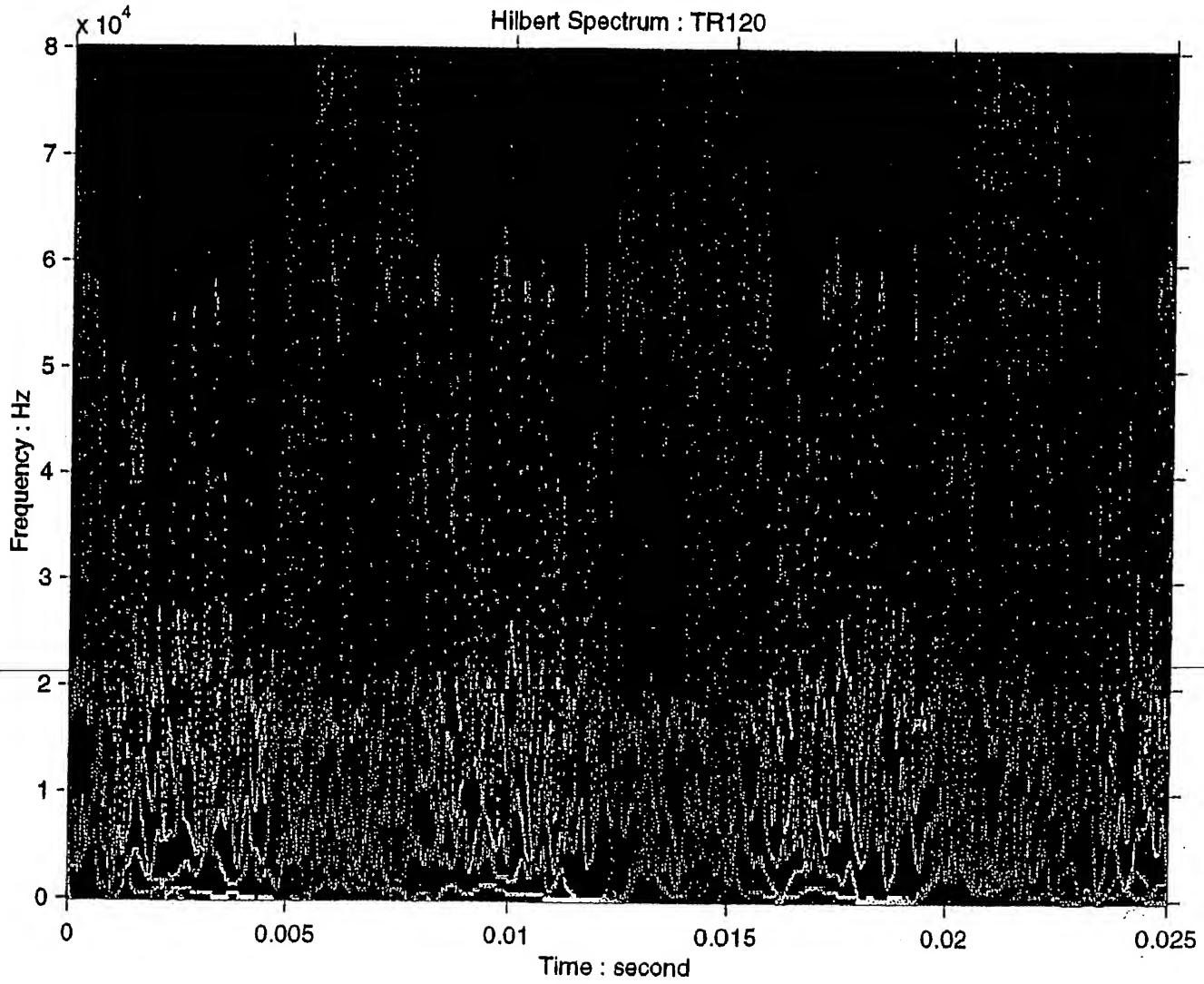
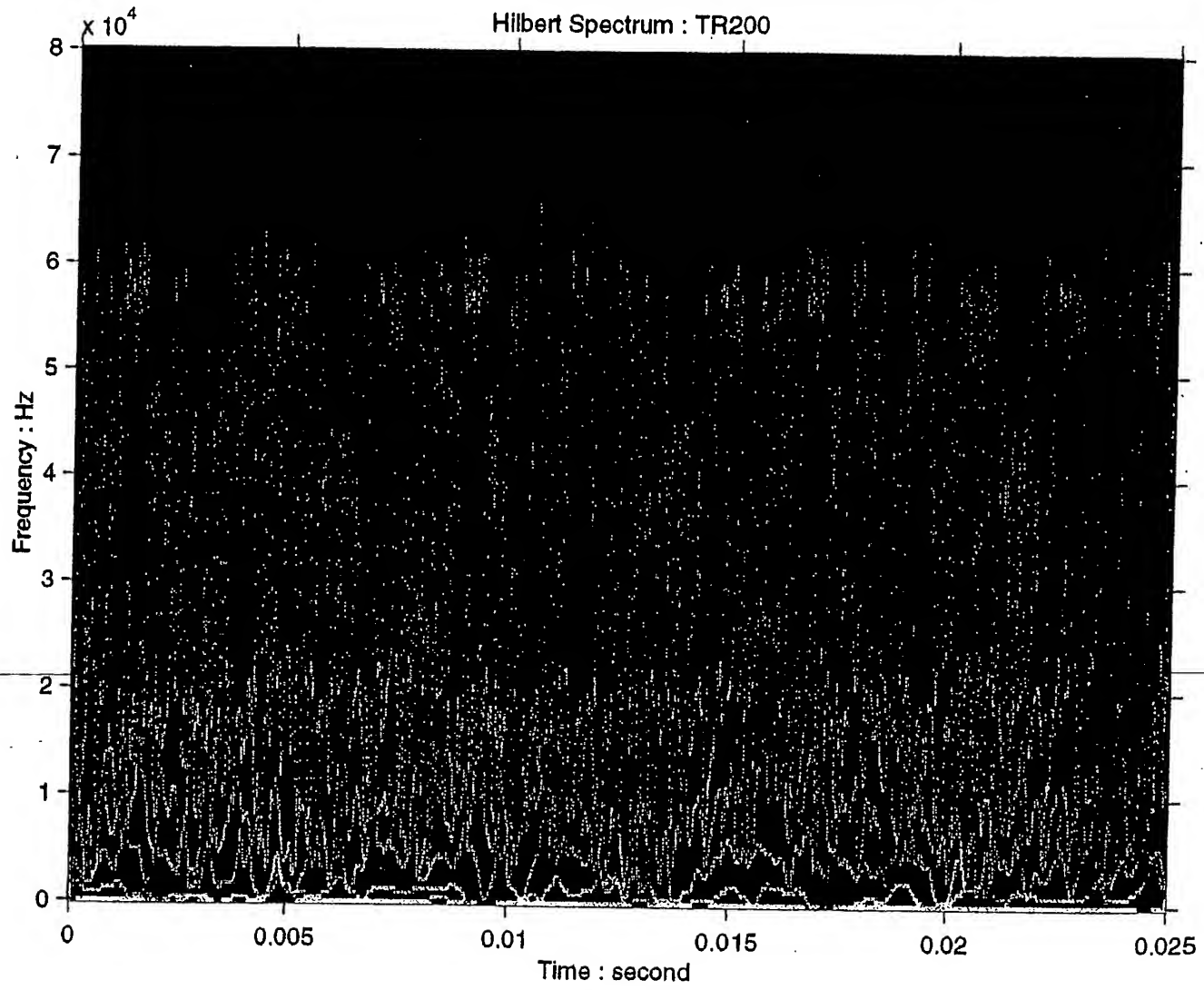

Hilbert Spectrum : TR120
X 10^4
8
7
6
5
4
3
2
1
0
Frequency : Hz
0
0.005
0.01
0.015
0.02
0.025
Time : second

FIG. 62(c)


Hilbert Spectrum : TR200
x 10^4
8
7
6
5
4
3
2
1
0
Frequency : Hz
0
0.005
0.01
0.015
0.02
0.025
Time : second